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TRIUMPHS OF

INVENTION AND DISCOVERY

IN ART AND SCIENCE.

GEORGE STEPHENSON'S HOME.

Page 120.

TRIUMPHS OF

INVENTION AND DISCOVERY

IN ART AND SCIENCE.

BY

J. HAMILTON FYFE.

"PEACE HATH HER VICTORIES NO LESS THAN WAR."

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Preface.

"*Peace hath her victories, no less renowned than war.*"—MILTON.

IT is not difficult to account for the pre-eminence generally assigned to the victories of war over the victories of peace in popular history. The noise and ostentation which attend the former, the air of romance which surrounds them,—lay firm hold of the imagination, while the directness and rapidity with which, in such transactions, the effect follows the cause, invest them with a peculiar charm for simple and superficial observers. As Schiller says,—

"Straight forward goes
The lightning's path, and straight the fearful path
Of the cannon ball. Direct it flies, and rapid,
Shattering that it *may* reach, and shattering what it reaches.
My son! the road the human being travels,
That on which blessing comes and goes, doth follow
The river's course, the valley's playful windings:
Curves round the corn-field and the hill of vines,
Honouring the holy bounds of property!
And thus secure, though late, leads to its end."

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The path of peace is long and devious, now dwindling into a mere foot-track, now lost to sight in some dense thicket; and the heroes who pursue it are often mocked at by the crowd as poor, half-witted souls, wandering either aimlessly or in foolish chase of some Jack o' lantern that ever recedes before them. The goal they aim at seems to the common eye so visionary, and their progress towards it so imperceptible,—and even when reached, it takes so long before the benefits of their achievement are generally recognised,—that it is perhaps no wonder we should be more attracted by the stirring narratives of war, than by the sad, simple histories of the great pioneers of industry and science.

Picturesque and imposing as deeds of arms appear, the victories of peace—the development of great discoveries and inventions, the performance of serene acts of beneficence, the achievements of social reform —possess a deeper interest and a truer romance for the seeing eye and the understanding heart. Wounds and death have to be encountered in the struggles of peace as well as in the contests of war; and

peace has her martyrs as well as her heroes. The story of the cotton-spinning invention is at once as tragic and romantic as the story of the Peninsular war. There were "forlorn hopes" of brave men in both; but in the one case they were cheered by sympathy and association, in the other the desperate pioneers had to face a world of foes, "alone, unfriended, solitary, slow."

The following pages contain sketches of some of the more momentous victories of peace, and the heroes who took part in them. The reader need hardly be reminded that this brief list does not exhaust the catalogue either of such events or persons, and that only a few of a representative character are here selected.

In the present edition the different sections have been carefully revised, and the details brought down to the latest possible date.

J. H. F.

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The Art of Printing.

I.—JOHN GUTENBERG.
II.—WILLIAM CAXTON.
III.—THE PRINTING MACHINE.

The Art of Printing.

"A creature he called to wait on his will,
Half iron, half vapour—a dread to behold—
Which evermore panted, and evermore rolled,
And uttered his words a millionfold.
Forth sprung they in air, down raining in dew,
And men fed upon them, and mighty they grew."

LEIGH HUNT, *Sword and Pen.*

I.—JOHN GUTENBERG.

SOME Dutch writers, inspired by a not unnatural feeling of patriotism, have endeavoured to claim the honour of inventing the Art of Printing for a countryman of their own, Laurence Coster of Haarlem. Their sole reliance, however, is upon the statements of one Hadrian Junius, who was born at Horn, in North Holland, in 1511. About 1575 he wrote a work, entitled "Batavia," in which the account of Coster first appeared. And, as an unimpeachable authority has remarked, almost every succeeding advocate of Coster's pretensions has taken the liberty

of altering, amplifying, or contradicting the account of Junius, according as it might suit his own line of argument; but not one of them has succeeded in producing a solitary fact in confirmation of it. The accounts which are given of Coster's discovery by Junius and his successors present many contradictory features. Thus Junius says: "Walking in a neighbouring wood, as citizens are accustomed to do after dinner and on holidays, he began to cut letters of beech-bark, with which, for amusement—the letters being inverted as on a seal—he impressed short sentences on paper for the children of his son-in-law." A later writer, Scriverius, is more imaginative: "Coster," he says, "walking in the wood, picked up a small bough of a beech, or rather of an oak-tree, blown off by the wind; and after amusing himself with cutting some letters on it, wrapped it up in paper, and afterwards laid himself down to sleep. When he awoke, he perceived that the paper, by a shower of rain or some accident having got moist, had received an impression from these letters; which induced him to pursue the accidental discovery."

Not only are these accounts evidently deficient in authenticity, but it should be remarked that the earliest of them was not put before the world until Laurence Coster had been nearly a hundred and fifty years in his grave. The presumed writer of the narrative which first did justice to his memory had

been also twelve years dead when his book was published. His information, or rather the information brought forward under cover of his name, was derived from an old man who, when a boy, had heard it from another old man who lived with Coster at the time of the robbery, and who had heard the account of the invention from his master. For, to explain the fact of the early appearance of typography in Germany, the Dutch writers are forced to the hypothesis that an apprentice of Coster's stole all his master's types and utensils, fleeing with them first to Amsterdam, second to Cologne, and lastly to Mentz! The whole story is too improbable to be accepted by any impartial inquirer; and the best authorities are agreed in dismissing the Dutch fiction with the contempt it deserves, and in ascribing to JOHN GUTENBERG, of Mentz, the honour to which he is justly entitled.

Of the career of Gutenberg we shall speak presently, but let us first point out that the invention of typography, like all great inventions, was no sudden conception of genius—not the birth of some singularly felicitous moment of inspiration—but the result of what may be called a gradual series of causes. Printing with movable types was the natural outcome of printing with blocks. We must go back, therefore, a few years, to examine into the origin of "block books."

Mr. Jackson observes that there cannot be a doubt that the principle on which wood engraving is founded—that of taking impressions on paper or parchment, with ink, from prominent lines—was known and practised in attesting documents in the thirteenth and fourteenth centuries. Towards the end of the fourteenth, or about the beginning of the fifteenth century, he says, there seems reason to believe that this principle was adopted by the German card-makers for the purpose of marking the outlines of the figures on their cards, which they afterwards coloured by the practice called *stencilling*.

It was the Germans who first practised card-making as a trade, and as early as 1418 the name of a *kartenmacher*, or card-maker, occurs in the burgess-books of Augsburg. In the town-books of Nuremburg, the designation *formschneider*, or figure-cutter, is found in 1449; and we may presume that block books—that is, books each page of which was cut on a single block—were introduced about this time. These books were on religious subjects, and were intended, perhaps, by the monks as a kind of counterbalance against the playing-cards; "thus endeavouring to supply a remedy for the evil, and extracting from the serpent a cure for his bite."

The earliest woodcut known—one of St. Christopher—bears the date of 1432, and was found in a convent situated within about fifty miles of the city of Augsburg—the convent of Buxheim, near Mem-

mingen. It was pasted on the inside of the right hand cover of a manuscript entitled *Laus Virginis*, and measures eleven and a quarter inches in height, by eight and one-eighth inches in width.

The following description of it by Jackson is interesting :—

"To the left of the engraving the artist has introduced, with a noble disregard of perspective, what Bewick would have called a 'bit of nature.' In the foreground a figure is seen driving an ass loaded with a sack towards a water-mill; while by a steep path a figure, perhaps intended for the miller, is seen carrying a full sack from the back-door of the mill towards a cottage. To the right is seen a hermit—known by the bell over the entrance to his dwelling—holding a large lantern to direct St. Christopher as he crosses the stream. The couplet at the foot of the cut,—

'Cristofori faciem die quacunque tueris,
Illa nempe die morte mala non morieris,'

may be translated as follows,—

Each day that thou the image of St. Christopher shall see,
That day no frightful form of death shall chance to fall on thee.

These lines allude to a superstition, once popular in all Catholic countries, that on the day they saw a figure or image of St. Christopher, they would be safe from a violent death, or from death unabsolved and unconfessed."

Passing over some other woodcuts of great antiquity, in all of which the figures are accompanied by engraved letters, we come to the block books proper. Of these, the most famous are called, the *Apocalypsis, seu Historia Sancti Johannis* (the "Apocalypse, or History of St. John"); the *Historia Virginis ex Cantico Canticorum* ("Story of the Virgin, from the Song of Songs); and the *Biblia Pauperum* ("Bible of the Poor"). The first is a history, pictorial and literal, of the life and revelations of St. John the Evangelist, partly derived from the book of Revelation, and partly from ecclesiastical tradition. The second is a similar biography of the Virgin Mary, as it is supposed to be typified in the Song of Solomon; and the third consists of subjects representing many of the most important passages in the Old and New Testaments, with texts to illustrate the subject, or clinch the lesson of duty it may shadow forth.

With respect to the engraving, we are told that the cuts are executed in the simplest manner, as there is not the least attempt at shading, by means of cross lines or hatchings, to be detected in any one of the designs. The most difficult part of the engraver's task, says Jackson, supposing the drawing to have been made by another person, would be the cutting of the letters, which, in several of the subjects, must have occupied a considerable portion of time, and have

demanded no small degree of perseverance, care, and skill.

These block books were followed by others in which no illustrations appeared, but in which the entire page was occupied with text. The Grammatical Primer, called the "Donatus," from the name of its supposed compiler, was thus printed, or engraved, enabling copies of it to be multiplied at a much cheaper rate than they could be produced in manuscript.

And thus we see that the art of printing—or, more correctly speaking, engraving on wood—has advanced from the production of a single figure, with merely a few words beneath it, to the impression of whole pages of text. Next, for the engraved page were to be substituted movable letters of metal, wedged together within an iron frame; and impressions, instead of being obtained by the slow and tedious process of friction, were to be secured by the swift and powerful action of the press.

About the year 1400, John Gænsfleisch, or Gutenberg, was born at Mentz. He sprung from an honourable family, and it is said that he himself was by birth a knight. He seems to have been a person of some property.

About 1434 we find him living in Strasburg, and, in partnership with a certain Andrew Drytzcher, endeavouring to perfect the art of typography. How

he was induced to direct his attention towards this object, and under what circumstances he began his experiments, it is impossible to say; but there can be no doubt that he was the first person who conceived the idea of *movable types*—an idea which is the very foundation of the art of printing.

An old German chronicler furnishes the following account of the early stages of the great printer's discovery:—

"At this time (about 1438), in the city of Mentz, on the Rhine, in Germany, and not in Italy as some persons have erroneously written, that wonderful and then unheard-of art of printing and characterizing books was invented and devised by John Gutenberger, citizen of Mentz, who, having expended most of his property in the invention of this art, on account of the difficulties which he experienced on all sides, was about to abandon it altogether; when, by the advice and through the means of John Fust, likewise a citizen of Mentz, he succeeded in bringing it to perfection. At first they formed or engraved the characters or letters in written order on blocks of wood, and in this manner they printed the vocabulary called a 'Catholicon.' But with these forms or blocks they could print nothing else, because the characters could not be transposed in these tablets, but were engraved thereon, as we have said. To this invention succeeded a more subtle one, for they found out the means of cutting the forms of all the

letters of the alphabet, which they called *matrices*, from which again they cast characters of copper or tin of sufficient hardness to resist the necessary pressure, which they had before engraved by hand."

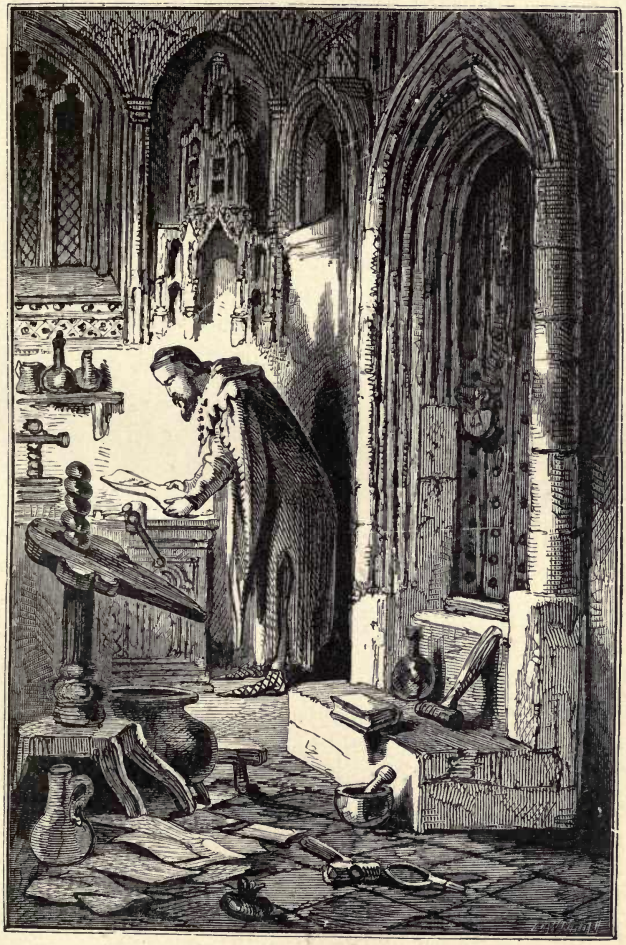
This is a very brief and summary account of a great invention. By comparison of other authorities we are enabled to bring together a far greater number of details, though we must acknowledge that many of these have little foundation but in tradition or romance.

Let us, therefore, take a peep at the first printer, working in seclusion and solitude in the old historic city of Strasburg, and endeavouring to elaborate in practice the grand idea which has been conceived and matured by his energetic brain. Doubtlessly he knew not the full importance of this idea, or of how great a social and religious revolution it was to be the seed, and yet we cannot believe that he was altogether unconscious of its value to future generations.

Shutting himself up in his own room, seeing no one, rarely crossing the threshold, allowing himself hardly any repose, he set himself to work out the plan he had formed. With a knife and some pieces of wood he constructed a set of movable types, on one face of each of which a letter of the alphabet was carved in relief, and which were strung together, in the order of words and sentences, upon a piece of wire. By means of these he succeeded in

producing upon parchment a very satisfactory impression.

To be out of the way of prying eyes, he took up his quarters in the ruins of the old monastery of St. Arbogaste, outside the town, which had long been abandoned by the monks to the rats and beggars of the neighbourhood; and the better to mask his designs, as well as to procure the funds necessary for his experiments, he set up as a sort of artificer in jewellery and metal-work, setting and polishing precious stones, and preparing Venetian glass for mirrors, which he afterwards mounted in frames of metal and carved wood. These avowed labours he openly practised, along with a couple of assistants, in a public part of the monastery; but in the depths of the cloisters, in a dark secluded spot, he fitted up a little cell as the *atelier* of his secret operations; and there, secured by bolts and bars, and a thick oaken door, against the intrusion of any one who might penetrate so far into the interior of the ruins, he applied himself to his great work. He quickly perceived, as a man of his inventiveness was sure to perceive, the superiority of letters of metal over those of wood. He invented various coloured inks, at once oily and dry, for printing with; brushes and rollers for transferring the ink to the face of the types; "forms," or cases, for keeping together the types arranged in pages; and a press for bringing the inked types and the paper in contact.



GUTENBERG IN THE OLD MONASTERY.

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Day and night, whenever he could spare an instant from his professed occupations, he devoted himself to the development of his great design. At night he could hardly sleep for thinking of it, and his hasty snatches of slumber were disturbed by agitating dreams. Tradition has preserved the story of one of these for us as he afterwards told it to his friends. He dreamt that, as he sat feasting his eyes upon the impression of his first page of type, he heard two voices whispering at his ear—the one soft and musical, the other harsh, dull, and bitter in its tones. The one bade him rejoice at the great work he had achieved; unveiled the future, and showed the men of different generations, the peoples of distant lands, holding high converse by means of his invention; and cheered him with the hope of an immortal fame. "Ay," put in the other voice, "immortal he might be, but at what a price! Man, more often perverse and wicked than wise and good, would profane the new faculty this art created, and the ages, instead of blessing, would have cause to curse the man who gave it to the world. Therefore let him regard his invention as a seductive but fatal dream, which, if fulfilled, would place in the hands of man, sinful and erring as he was, only another instrument of evil." Gutenberg, whom the first voice had thrown into an ecstasy of delight, now shuddered at the thought of the fearful power to corrupt and to debase his art would give to wicked men, and

awoke in an agony of doubt. He seized his mallet, and had almost broken up his types and press, when he paused to reflect that, after all, God's gifts, although sometimes perilous and capable of abuse, were never evil in themselves, and that to give another means of utterance to the piety and reason of mankind was to promote the spread of virtue and intelligence, which were both divine. So he closed his ears to the suggestions of the tempter, and persisted in his work.

Gutenberg had scarcely completed his printing machine, and got it into working order, when the jealousy and distrust of his associates in the nominal business he carried on, brought him into trouble with the authorities of Strasburg. He could have saved himself by the disclosure of all the secrets of his invention; but this he refused to do. His goods were confiscated; and he returned penniless, with a heavy heart, to his native town Mentz. There, in partnership with a wealthy goldsmith named John Fust, and his son-in-law Schoeffer, he started a printing office; from which he sent out many works, mostly of a religious character. The enterprise throve; but misfortune was ever dogging Gutenberg's steps, and he had but a brief taste of prosperity. The priests looked with suspicion upon the new art, which enabled people to read for themselves what before they had to take on trust from them. The transcribers of books,—a large and influential

guild,—were also hostile to the invention, which threatened to deprive them of their livelihood. These two bodies formed a league against the printers; and upon the head of poor Gutenberg were emptied all the vials of their wrath. Fust and Schoeffer, with crafty adroitness, managed to conciliate their opponents, and to offer up their partner as a sacrifice for themselves. By the zeal of his enemies, and the treachery of his friends, Gutenberg was driven out of Mentz. After wandering about for some time in poverty and neglect, Adolphus, the Elector of Nassau, became his patron; and at his court Gutenberg set up a press, and printed a number of works with his own hands. Though poor, his last years were spent in peace; and when he died, he had only a few copies of the productions of his press to leave to his sister.

Meanwhile, at Strasburg, some of his former associates pieced together the revelations that had fallen from him, while at the old monastery, as to his invention; and not only worked it with success, but claimed all the credit of its origin. In the same way, Fust and Schoeffer, at Mentz, grew rich through the invention of the man they had betrayed, and tried to rob of his fame.

There is a curious, but not very well authenticated story about a visit Fust made to Paris to push the sale of his Bibles. "The tradition of the Devil and Dr. Faustus," writes D'Israeli in the "Curiosities of Litera-

ture," "was said to have been derived from the odd circumstances in which the Bibles of the first printer, Fust, appeared to the world. When Fust had discovered this new art, and printed off a considerable number of copies of the Bible to imitate those which were commonly sold as MSS., he undertook the sale of them at Paris. It was his interest to conceal this discovery and to pass off his printed copies for MSS. But, enabled to sell his Bibles at sixty crowns, while the other scribes demanded five hundred, this raised universal astonishment; and still more when he produced copies as fast as they were wanted, and even lowered his price. The uniformity of the copies increased the wonder. Informations were given in to the magistrates against him as a magician; and on searching his lodgings, a great number of copies were found. The red ink, and Fust's red ink is peculiarly brilliant, which embellished his copies, was said to be his blood; and it was solemnly adjudged that he was in league with the Infernal. Fust at length was obliged, to save himself from a bonfire, to reveal his art to the Parliament of Paris, who discharged him from all prosecution in consideration of the wonderful invention."

The edition of the Bible, which was one of the very first productions of Gutenberg and Fust's press, is called the Mazarin, in consequence of the first known copy having been discovered in the famous library formed by Cardinal Mazarin. It seems to

have been printed as early as August 1456, and is a truly admirable specimen of typography; the characters being very clear and distinct, and the uniformity of the printing perfectly remarkable. A copy in the Royal Library at Paris is bound in two volumes, and every complete page consists of two columns, each containing forty-two lines. The reader will recognize the appropriateness of the fact that from the first printing press the first important work produced should be a copy of God's Word. It sanctified the new art which was to be so fruitful of good and evil results—the good superabounding, and clearly visible—the evil little, and destined, perhaps, to be directed eventually to good—for successive generations of mankind. It was a fitting forerunner of the long generation of books which have since issued so ceaselessly from the printing press; books, of the majority of which we may say, with Milton, that "they contain a potency of life in them to be as active as those souls were whose progeny they are; to preserve, as in a vial, the purest efficacy and extraction of the living intellects that feed them."

Gutenberg's career was dashed with many lights and shadows, but it closed in peace. In 1465, the Archbishop-elector of Mentz appointed him one of his courtiers, with the same allowance of clothing as the remainder of the nobles attending his court, and all other privileges and exemptions. It is pro-

bable that from this time he abandoned the practice of his new invention. The date of his death is uncertain; but there is documentary evidence extant which proves that it occurred before February 24, 1468. He was interred in the church of the Recollets at Mentz, and the following epitaph was composed by his kinsman Adam Gelthaus :—

"D. O. M. S.

"Joanni Gesnyfleisch, artis impressoriae repertori, de omni natione et lingua optime merito, in nominis sui memoriam immortalem Adam Gelthaus posuit. Ossa ejus in ecclesia D. Francisci Moguntina feliciter cubant."

II.—WILLIAM CAXTON.

During the last thirty or forty years of the fifteenth century, while printing was becoming gradually more and more practised on the Continent, and the presses of Mentz, Bamberg, Cologne, Strasburg, Augsburg, Rome, Venice, and Milan, were sending forth numbers of Bibles, and various learned and theological works, chiefly in Latin, an English merchant, a man of substance and of no little note in Chepe, appeared at the court of the Duke of Burgundy at Bruges, to negotiate a commercial treaty between that sovereign and the king of England; which accomplished, the worthy ambassador seems to have liked the place and the people so well, and to have been so much liked in return, that for some years afterwards he took up his residence there, holding some honourable, easy

appointment in the household of the Duchess of Burgundy. This was William Caxton, who here ripened, if he did not acquire, his love of literature and scholarship, and began, from hatred of idleness, to take pen in hand himself.

"When I remember," says he, in his preface to his first work, a translation of a fanciful "Recueil des Histoires de Troye," "that every man is bounden by the commandment and counsel of the wise man to eschew sloth and idleness, which is mother and nourisher of vices, and ought to put himself into virtuous occupation and business, then I, having no great charge or occupation, following the said counsel, took a French book, and read therein many strange marvellous histories. And for so much as this book was new and late made, and drawn into French, and never seen in our English tongue, I thought in myself, it should be a good business to translate it into our English, to the end that it might be had as well in the royaume of England as in other lands, and also to pass therewith the time; and thus concluded in myself to begin this said work, and forthwith took pen and ink, and began boldly to run forth, as blind Bayard, in this present work."

While at work upon this translation, Caxton found leisure to visit several of the German towns where printing presses were established, and to get an insight into the mysteries of the art, so that by the time he had finished the volume, he was able to

print it. At the close of the third book of the "Recuyell," he says: "Thus end I this book which I have translated after mine author, as nigh as God hath given me cunning, to whom be given the laud and praise. And for as much as in the writing of the same my pen is worn, mine hand weary and not steadfast, mine eyen dimmed with overmuch looking on the white paper, and my courage not so prone and ready to labour as it hath been, and that age creepeth on me daily, and feebleth all the body; and also because I have promised to divers gentlemen and to my friends, to address to them as hastily as I might, this said book, therefore I have practised and learned, at my great charge and dispense, to ordain this said book in print, after the manner and form you may here see; and is not written with pen and ink as other books are, to the end that every man may have them at once. For all the books of this story, named the "Recuyell of the Historyes of Troye," thus imprinted as ye here see, were begun in one day, and also finished in one day" (that is, in the same space of time).

By the year 1477, Caxton had returned to London, and set up a printing establishment within the precincts of Westminster Abbey; had given to the world the three first books ever printed in England, —"The Game and Play of the Chesse" (March 1474); "A boke of the hoole Lyf of Jason" (1475); and "The Dictes and Notable Wyse Sayenges of the

WILLIAM CAXTON.

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Phylosophers" (1477),—and was fairly started in the great work of supplying printed books to his countrymen, which, as a placard in his largest type sets forth, if any one wanted, "emprynted after the forme of this present lettre whiche ben well and truly correct, late hym come to Westmonster, in to the Almonesrye, at the reed pale, and he shal have them good chepe." From the situation of the first printing office, the term chapel is applied to such establishments to this day.

Caxton published between sixty and seventy different works during the seventeen years of his career as a printer, all of them in what is called black letter, and the bulk of them in English. He had always a view to the improvement of the people in the works he published, and though many of his productions may seem to us to be of an unprofitable kind, it is clear that in the issue of chivalrous narratives, and of Chaucer's poems (to whom, says the old printer, "ought to be given great laud and praising for his noble making and writing"), he was aiming at the diffusion of a nobler spirit, and a higher taste than then prevailed.

In 1490, Caxton, an old, worn man, verging on fourscore years of age, wrote, "Every man ought to intend in such wise to live in this world, by keeping the commandments of God, that he may come to a good end; and then, out of this world full of wretchedness and tribulation, he may go to heaven,

unto God and his saints, unto joy perdurable ;" and passed away, still labouring at his post. He died while writing, "The most virtuous history of the devout and right renouned Lives of Holy Fathers living in the desert, worthy of remembrance to all well-disposed persons."

Wynkyne de Worde filled his master's place in the almonry of Westminster ; and the guild of printers gradually waxed strong in numbers and influence. In Germany they were privileged to wear robes trimmed with gold and silver, such as the nobles themselves appeared in ; and to display on their escutcheon, an eagle with wings outstretched over the globe,—a symbol of the flight of thought and words throughout the world. In our own country, the printers were men of erudition and literary acquirements ; and were honoured as became their mission.

III.—THE PRINTING MACHINE.

Between the rude screw-press of Gutenberg or Caxton, slow and laboured in its working, to the first-class printing machine of our own day, throwing off its fifteen or eighteen thousand copies of a large four-page journal in an hour, what a stride has been taken in the noble art ! Step by step, slowly but surely, has the advance been made,—one improvement suggested after another at long intervals, and by various minds. With the perfection of the

printing press, the name of Earl Stanhope is chiefly associated; but, although when he had put the finishing touches to its construction, immensely superior to all former machines, it was unavailable for rapid printing. In relation to the demand for literature and the means of supplying it, the world had, half a century ago, reached much the same deadlock as in the days when the production of books depended solely on the swiftness of the transcriber's pen, and when the printing press existed only in the fervid brain and quick imagination of a young German student. Not only the growth, but the spread of literature, was restricted by the labour, expense, and delay incident to the multiplication of copies; and the popular appetite for reading was in that transition state when an increased supply would develop it beyond all bounds or calculation, while a continuance of the starvation supply would in all likelihood throw it into a decline from want of exercise.

Such was the state of things when a revolution in the art of printing was effected which, in importance, can be compared only to the original discovery of printing. In fact, since the days of Gutenberg to the present hour, there has been only one great revolution in the art, and that was the introduction of steam printing in 1814. The neat and elegant, but slow-moving Stanhope press, was after all but little in advance of its rude prototype

of the fifteenth century, the chief features of which it preserved almost without alteration. The steam printing machine took a leap ahead that placed it at such a distance from the printing press, that they are hardly to be recognised as the offspring of the same common stock. All family resemblance has died out, although the printing machine is certainly a development of the little screw press.

Of the revolution of 1814, which placed the printing machine in the seat of power, *vice* the press given over to subordinate employment, Mr. John Walter of the *Times* was the prominent and leading agent. But for his foresight, enterprise, and perseverance, the steam machine might have been even now in earliest infancy, if not unborn.

Familiar as the invention of the steam printing machine is now, in the beginning of the present century it shared the ridicule which was thrown upon the project of sailing steam ships upon the sea, and driving steam carriages upon land. It seemed as mad and preposterous an idea to print off 5000 impressions of a paper like the *Times* in one hour, as, in the same time, to paddle a ship fifteen miles against wind and tide, or to propel a heavily laden train of carriages fifty miles. Mr. Walter, however, was convinced that the thing could be done, and lost no time in attempting it. Some notion of the difficulties he had to overcome, and the disappointments he had to endure, while engaged in this enter-

prise, may be gathered from the following extracts from the biography of Mr. Walter, which appeared in the *Times* at the time of his death in July 1847:—

"As early as the year 1804, an ingenious compositor, named Thomas Martyn, had invented a self-acting machine for working the press, and had produced a model which satisfied Mr. Walter of the feasibility of the scheme. Being assisted by Mr. Walter with the necessary funds, he made considerable progress towards the completion of his work, in the course of which he was exposed to much personal danger from the hostility of the pressmen, who vowed vengeance against the man whose inventions threatened destruction to their craft. To such a length was their opposition carried, that it was found necessary to introduce the various pieces of the machine into the premises with the utmost possible secresy, while Martyn himself was obliged to shelter himself under various disguises in order to escape their fury. Mr. Walter, however, was not yet permitted to reap the fruits of his enterprise. On the very eve of success he was doomed to bitter disappointment. He had exhausted his own funds in the attempt, and his father, who had hitherto assisted him, became disheartened, and refused him any further aid. The project was, therefore, for the time abandoned.

"Mr. Walter, however, was not the man to be deterred from what he had once resolved to do. He

gave his mind incessantly to the subject, and courted aid from all quarters, with his usual munificence. In the year 1814 he was induced by a clerical friend, in whose judgment he confided, to make a fresh experiment; and, accordingly, the machinery of the amiable and ingenious Kœnig, assisted by his young friend Bower was introduced—not, indeed, at first into the *Times* office, but into the adjoining premises, such caution being thought necessary upon the threatened violence of the pressmen. Here the work advanced, under the frequent inspection and advice of the friend alluded to. At one period these two able mechanics suspended their anxious toil, and left the premises in disgust. After the lapse, however, of about three days, the same gentleman discovered their retreat, induced them to return, showed them, to their surprise, their difficulty conquered, and the work still in progress. The night on which this curious machine was first brought into use in its new abode was one of great anxiety, and even alarm. The suspicious pressmen had threatened destruction to any one whose inventions might suspend their employment. 'Destruction to him and his traps.' They were directed to wait for expected news from the Continent. It was about six o'clock in the morning when Mr. Walter went into the press-room, and astonished its occupants by telling them that 'The *Times* was already printed by steam! That if they attempted violence, there was a force ready

to suppress it; but that if they were peaceable, their wages should be continued to every one of them till similar employment could be procured,'—a promise which was, no doubt, faithfully performed; and having so said, he distributed several copies among them. Thus was this most hazardous enterprise undertaken and successfully carried through, and printing by steam on an almost gigantic scale given to the world."

On that memorable day, the 29th of November 1814, appeared the following announcement,—"Our journal of this day presents to the public the practical result of the greatest improvement connected with printing since the discovery of the art itself. The reader now holds in his hands one of the many thousand impressions of the *Times* newspaper which were taken off last night by a mechanical apparatus. That the magnitude of the invention may be justly appreciated by its effects, we shall inform the public that after the letters are placed by the compositors, and enclosed in what is called a form, little more remains for man to do than to attend and watch this unconscious agent in its operations. The machine is then merely supplied with paper; itself places the form, inks it, adjusts the paper to the form newly inked, stamps the sheet, and gives it forth to the hands of the attendant, at the same time withdrawing the form for a fresh coat of ink, which itself again distributes, to meet the ensuing sheet, now

advancing for impression; and the whole of these complicated acts is performed with such a velocity and simultaneousness of movement, that no less than 1100 sheets are impressed in one hour."

Kœnig's machine was, however, very complicated, and before long, it was supplanted by that of Applegath and Cowper, which was much simpler in construction, and required only two boys to attend it—one to lay on, and the other to take off the sheets. The vertical machine which Mr. Applegath subsequently invented, far excelled his former achievement; but it has in turn been superseded by the machine of Messrs. Hoe of New York. All these machines were first brought into use in the *Times'* printing office; and to the encouragement the proprietors of that establishment have always afforded to inventive talent, the readiness with which they have given a trial to new machines, and the princely liberality with which they have rewarded improvements, is greatly due the present advanced state of the noble craft and mystery.

The printing-house of the *Times*, near Blackfriars Bridge, forms a companion picture to Gutenberg's printing-room in the old abbey at Strasburg, and illustrates not only the development of the art, but the progress of the world during the intervening centuries. Visit Printing-House Square in the daytime, and you find it a quiet, sleepy place, with hardly any signs of life or movement about it, except

in the advertisement office in the corner, where people are continually going out and in, and the clerks have a busy time of it, shovelling money into the till all day long. But come back in the evening, and the place will wear a very different aspect. All signs of drowsiness have disappeared, and the office is all lighted up, and instinct with bustle and activity. Messengers are rushing out and in, telegraph boys, railway porters, and "devils" of all sorts and sizes. Cabs are driving up every few minutes, and depositing reporters, hot from the gallery of the House of Commons or the House of Lords, each with his budget of short-hand notes to decipher and transcribe. Up stairs in his sanctum the editor and his deputies are busy preparing or selecting the articles and reports which are to appear in the next day's paper. In another part of the building the compositors are hard at work, picking up types, and arranging them in "stick-fulls," which being emptied out into "galleys," are firmly fixed therein by little wedges of wood, in order that "proofs" may be taken of them. The proofs pass into the hands of the various sets of readers, who compare them with the "copy" from which they were set up, and mark any errors on the margin of the slips, which then find their way back to the compositors, who correct the types according to the marks. The "galleys" are next seized by the persons charged with the "making-up" of the paper, who divide them into

columns of equal length. An ordinary *Times* newspaper, with a single inside sheet of advertisements, contains seventy-two columns, or 17,500 lines, made up of upwards of a million pieces of types, of which matter about two-fifths are often written, composed, and corrected after seven o'clock in the evening. If the advertisement sheet be double, as it frequently is, the paper will contain ninety-six columns. The types set up by the compositors are not sent to the machine. A mould is taken of them in a composition of brown paper, by means of which a "stereotype" is cast in metal, and from this the paper is printed. The advertisement sheet, single or double, as the case may be, is generally ready for the press between seven or eight o'clock at night. The rest of the paper is divided into two "forms,"—that is, columns arranged in pages and bound together by an iron frame, one for each side of the sheet. Into the first of these the person who "makes up" the paper endeavours to place all the early news, and it is sent to press usually about four o'clock. The other "form" is reserved for the leading articles, telegrams, and all the latest intelligence, and does not reach the press till near five o'clock.

The first sight of Hoe's machine, by several of which the *Times* is now printed, fills the beholder with bewilderment and awe. You see before you a huge pile of iron cylinders, wheels, cranks, and levers, whirling away at a rate that makes you

giddy to look at, and with a grinding and gnashing of teeth that almost drives you deaf to listen to. With insatiable appetite the furious monster devours ream after ream of snowy sheets of paper, placed in its many gaping jaws by the slaves who wait on it, but seems to find none to its taste or suitable to its digestion, for back come all the sheets again, each with the mark of this strange beast printed on one side. Its hunger never is appeased,—it is always swallowing and always disgorging, and it is as much as the little "devils" who wait on it can do, to put the paper between its lips and take it out again. But a bell rings suddenly, the monster gives a gasp, and is straightway still, and dead to all appearance. Upon a closer inspection, now that it is at rest, and with some explanation from the foreman you begin to have some idea of the process that has been going on before your astonished eyes.

The core of the machine consists of a large drum, turning on a horizontal axis, round which revolve ten smaller cylinders, also on horizontal axes, in close proximity to the drum. The stereotyped matter is bound, like a malefactor on the wheel, to the central drum, and round each cylinder a sheet of paper is constantly being passed. It is obvious, therefore, that if the type be inked, and each of the cylinders be kept properly supplied with a sheet of paper, a single revolution of the drum will cause the ten cylinders to revolve likewise, and produce an impression on one

side of each of the sheets of paper. For this purpose it is necessary to have the type inked ten times during every revolution of the drum; and this is managed by a very ingenious contrivance, which, however, is too complicated for description here. The feeding of the cylinders is provided for in this way. Over each cylinder is a sloping desk, upon which rests a heap of sheets of white paper. A lad—the "layer-on"—stands by the side of the desk and pushes forward the paper, a sheet at a time, towards the tape fingers of the machine, which, clutching hold of it, drag it into the interior, where it is passed round the cylinders, and printed on the outer side by pressure against the types on the drum. The sheet is then laid hold of by another set of tapes, carried to the other end of the machine from that at which it entered, and there laid down on a desk by a projecting flapper of lath-work. Another lad—the "taker-off"—is in attendance to remove the printed sheets, at certain intervals. The drum revolves in less than two seconds; and in that time therefore ten sheets—for the same operation is performed simultaneously by the ten cylinders—are sucked in at one end and disgorged at the other printed on one side, thus giving about 20,000 impressions in an hour.

Such is the latest marvel of the "noble craft and mystery" of printing; but it is not to be supposed that the limits of production have even now been reached. The greater the supply the greater has

grown the demand; the more people read, the more they want to read; and past experience assures us that ingenuity and enterprise will not fail to expand and multiply the powers of the press, so that the increasing appetite for literature may be fully met.

We have briefly alluded to stereotyping; but some fuller notice seems requisite of a process so valuable and important, without which, indeed, the rapid multiplication of copies of a newspaper, even by a Hoe's six-cylinder machine, would be impossible. If stereotyping had not been invented, the printer would require to "set up" as many "forms" of type as there are cylinders in the machines he uses; an expensive and time-consuming operation which is now dispensed with, because he can resort to "casts." There is yet another advantage gained by the process; "casts" of the different sheets of a book can be preserved for any length of time; and when additional copies or new editions are needed, these "casts" can at once be sent to the machine, and the publisher is saved the great expense of "re-setting."

The reader is well aware that while many books disappear with the day which called them forth, so there are others for which the demand is constant. This was found to be the case soon after the invention of printing, and the plan then adopted was the expensive and cumbrous one of setting up the whole

of the book in request, and to keep the type standing for future editions. The disadvantages of this plan were obvious—a large outlay for type, the amount of space occupied by a constantly increasing number of "forms," and the liability to injury from the falling out of letters, from blows, and other accidents. As early as the eighteenth century attempts seem to have been made to remedy these inconveniences by cementing the types together at the bottom with lead or solder to effect their greater preservation. Canius, a French historian of printing, states that in June 1801 he received a letter from certain booksellers of Leyden, with a copy of their stereotype Bible, the plates for which were formed by soldering together the bottom of common types with some melted substance to the thickness of about three quires of writing-paper; and, it is added, "These plates were made about the beginning of the last century by an artist named Van du Mey."

This, however, was not true stereotyping; whose leading principle is to dispense with the movable types—to set them again, as it were, at liberty—by making up perfect fac-similes in type-metal of the various combinations into which they may have entered. These fac-similes being made, the type is set free, and may be distributed, and used for making up fresh pages; which may once more furnish, so to speak, the punches to the mould into which the type-metal is poured for the purpose of effecting the fac-simile.

The inventor of this ingenious process of casting plates from pages of type was William Ged, a goldsmith of Edinburgh, in 1735. Not possessing sufficient capital to carry out his invention, he visited London, and sought the assistance of the London stationers; from whom he received the most encouraging words, but no pecuniary assistance. But Ged was a man not readily discomfited, and applying at length to the Universities and the King's printer, he obtained the effective patronage he needed. He "stereotyped" some Bibles and Prayer-books, and the sheets worked off from his plates were admitted equal in point of appearance and accuracy to those printed from the type itself.

But every benefactor of his kind is doomed to meet with the opposition of the envious, the ignorant, or the prejudiced. "The argument used by the idol-makers of old, 'Sirs, ye know that by this craft we have our wealth,' and, 'This our craft is in danger to be set at nought,' was, as is usual in such cases, urged against this most useful and important invention. The compositors refused to set up works for stereotyping, and even those which were set up, however carefully read and corrected, were found to be full of gross errors. The fact was, that when the pages were sent to be cast, the compositors or pressmen, bribed, it is said, by a typefounder, disturbed the type, and introduced false letters and

words. Poor Ged died, and left the dangerous secret of his art (which he did not disclose during his life-time) to his son, who, after many struggles for success, failed as his father had done before him." There is a tradition current, however, that he joined the Jacobite rebellion, was arrested, imprisoned, tried, and sentenced, but was eventually spared in consideration of the value of his father's admirable invention.

That invention, after being forgotten for nearly half a century, was revived by a Dr. Tilloch, and taken up, improved, and extended by the ingenious Earl Stanhope. It is now practised in the following manner:—

The type employed differs slightly from that in common use. The letter should have no shoulder, but should rise in a straight line from the foot; the spaces, leads, and quadrats are of the same height as the stem of the letter; the object being to diminish the number and depth of the cavities in the page, and thus lessen the chances of the mould breaking off and remaining in the form. Each page is corrected with the utmost care, and "imposed" in a small "chase" with metal furniture (or frame-work), which rises to a level with the type. Of course the number of pages in the form will vary according to the size of the book; a sheet being folded into sixteen leaves, twelve, eight, four, or two for 16mo, 12mo, 8vo, quarto, or folio.

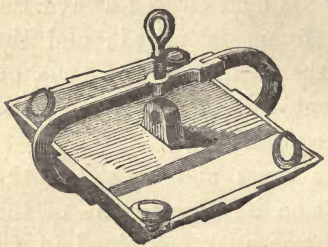
Having our pages of type in complete order, we now proceed to rub the surface with a soft brush which has been lightly dipped into a very thin oil. Plumbago is sometimes preferred. A brass rectangular frame of three sides, with bevelled borders adapted to the size of the pages, is placed upon the chase so as to enclose three sides of the type, the fourth side being formed by a single brass edge, having the same inward sloping level as the other three sides. The use of this frame is to determine the size and thickness of the cast, which is next taken in plaster-of-paris—two kinds of the said plaster being used; the finer is mixed, poured over the surface of the type, and gently worked in with a brush so as to insure its close adhesion to the exclusion of bubbles of air; the coarser, after being mixed with water, is simply poured and spread over the previous and finer stratum.

The superfluous plaster is next cleared away; the mould soon sets; the frame is raised; and the mould comes off from the surface of the type, on which it has been prevented from encrusting itself by the thin film of oil or plumbago.

The next step is to dress and smoothen the plaster-mould, and set it on its edge in one of the compartments of a sheet-iron rack contained in an oven, and exposed, until perfectly dry, to a temperature of about 400°. This occupies about two hours. A good workman, it is said, will mould ten octavo

sheets, or one hundred and sixty pages in a day: each mould generally contains a couple of octavo pages.

In the state to which it is now brought, the mould is exceedingly friable, and requires to be handled with becoming care. With the face downwards it is placed upon the flat cast-iron *floating-plate*, which, in its turn, is set at the bottom of a square cast-iron tray, with upright edges sloping outwards, called the "dipping pan." It has a cast-iron lid, secured by a screw and shackles, not unlike a copying machine. This pan having been heated to 400°, it is plunged into an iron pot containing the melted alloy, which hangs over a furnace, the pan being slightly inclined so as to permit the escape of the air. A small space is left between the back or upper surface of the mould, and the lid of the dipping-pan, and the fluid metal on entering into the pan through the corner openings, *floats* up the plaster together with the iron plate (hence called the *floating-plate*) on which the mould is set, with this effect, that the metal flows through the notches cut in the edge of the mould, and fills up every part of it, forming a layer of metal on its face corresponding to the depth of



the border, while on the back is left merely a thin metallic film.

The dipping-pan, says Tomlinson, is suspended, plunged in the metal, and removed by means of a crane; and when taken out, is set in a cistern of water upon supports so arranged that only the bottom of the pan comes in contact with the surface of the water. The metal thus *sets*, or solidifies, from below, and containing fluid above, maintains a fluid pressure during the contraction which accompanies the cooling.

As it thus shrinks in dimensions, molten metal is poured into the corners of the pan for the purpose of maintaining the fluid pressure on the mould, and thus securing a good and solid cast. For if the pan were allowed to cool more slowly, the thin metallic film at the back of the inverted plaster mould would probably solidify first, and thus prevent the fluid pressure which is necessary for filling up all the lines of the mould.

Tomlinson concludes his description of these interesting processes by informing us that an experienced and skilled workman will make five dips, each containing two octavo pages, in the course of an hour, or, as already stated, at the rate of nearly ten octavo sheets a day.

When the pan is opened, the cake of metal and plaster is removed, and beaten upon its edges with a mallet, to clear away all superfluous metal. The

stereotype plate is then taken by the *picker*, who planes its edges square, "turns" its back flat upon a lathe until the proper thickness is obtained, and removes any minute imperfections arising from specks of dirt and air-bubbles left among the letters in casting the mould. Damaged letters are cut out, and separate types soldered in as substitutes. After all this anxious care to obtain perfection, the plate is pronounced ready for working, and when made up with the other plates into the proper form, it may be worked either at the hand-press or by machine.

Other modes of stereotyping have been introduced, but not one has attained to the popularity of the method we have just described.

The Steam Engine.

I.—THE MARQUIS OF WORCESTER.
II.—JAMES WATT.

The Steam Engine.

"It is said that ideas produce revolutions: and truly they do—not spiritual ideas only, but even mechanical."—CARLYLE.

I.—THE MARQUIS OF WORCESTER.

As the last century was drawing to its close, two great revolutions were in progress, both of which were destined to exercise a mighty influence upon the years to come,—the one calm, silent, peaceful, the other full of sound and fury, bathed in blood, and crowned with thorns,—the one the fruit of long years of patient thought and work, the other the outcome of long years of oppression, suffering, and sin,—the one was Watt's invention of the steam engine, the other the great popular revolt in France. These are the two great events which set their mark upon our century, gave form and colour to its character, and direction to its aims and aspirations. In the pages of conventional history, of course, the French revolution, with its wild phantasmagoria of retribution, its massacres and martyrdoms, will no doubt have assigned to it the foremost rank as the great feature of the era,—

"For ever since historians writ,
And ever since a bard could sing,
Doth each exalt with all his wit
The noble art of murdering."

But those who can look below the mere surface of events, and whose fancy is not captivated by the melo-drama of rebellion, and the pageantry of war, will find that Watt's steam machine worked the greatest revolution of modern times, and exercised the deepest, as well as widest and most permanent influence over the whole civilized world.

Like all great discoveries, that of the motive power of steam, and the important uses to which it might be applied, was the work, not of any one mind, but of several minds, each borrowing something from its predecessor, until at last the first vague and uncertain Idea was developed into a practical Reality. Known dimly to the ancients, and probably employed by the priests in their juggleries and pretended miracles, it was not till within the last three centuries that any systematic attempt was made to turn it to useful account.

But before we turn our attention to the persons who made, and, after many failures and discouragements, *successfully* made this attempt, it will be advisable we should say something as to the principle on which their invention is founded.

The reader knows that gases and vapours, when imprisoned within a narrow space, do struggle as resolutely to escape as did Sterne's starling from his cage. Their force of pressure is enormous, and if confined in a closed vessel, they would speedily rend it into fragments. Let some water boil in a

pipkin whose lid fits very tightly; in a few minutes the vapour or steam arising from the boiling water, overcoming the resistance of the lid, raises it, and rushes forth into the atmosphere.

Take a small quantity of water, and pour it into the hollow of a ball of metal. Then with the aid of a cork, worked by a metallic screw, close the opening of the ball hermetically, and place the ball in the heart of a glowing fire. The steam formed by the boiling water in the inside of the metallic bomb, finding no channel of escape, will burst through the bonds that sought to confine it, and hurl afar the fragments with a loud and dangerous explosion.

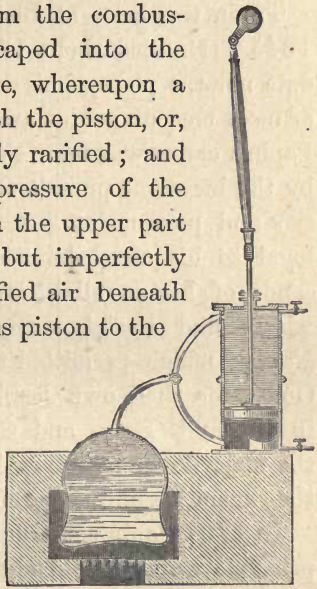
These well-known facts we adduce simply as a proof of the immense mechanical power possessed by steam when enclosed within a limited area. Now, the questions must have occurred to many, though they were themselves unable to answer them,—Why should all this force be wasted? Can it not be directed to the service and uses of man? In the course of time, however, human intelligence *did* discover a sufficient reply, and *did* contrive to utilize this astonishing power by means of the machine now so famous as the Steam Engine.

Let us take a boiler full of water, and bring it up to boiling point by means of a furnace. Attach to this boiler a tube, which guides the steam of the boiler into a hollow metallic cylinder, tra-

versed by a piston rising and sinking in its interior. It is evident that the steam rushing through the tube into the lower part of the cylinder, and underneath the piston, will force the piston, by its pressure, to rise to the top of the cylinder. Now let us check for a moment the influx of the steam *below* the piston, and turning the stopcock, allow the steam which fills that space to escape outside; and, at the same time, by opening a second tube, let in a supply of steam *above* the piston: the pressure of the steam, now exercised in a downward direction, will force the piston to the bottom of its course, because there will exist beneath it no resistance capable of opposing the pressure of the steam. If we constantly keep up this alternating motion, the piston now rising and now falling, we are in a position to profit by the force of steam. For if the lever, attached to the rod of the piston at its lower end, is fixed by its upper to a crank of the rotating axle of a workshop or factory, is it not clear that the continuous action of the steam will give this axle a continuous rotatory movement? And this movement may be transmitted, by means of bands and pulleys, to a number of different machines or engines all kept at work by the power of a solitary engine.

This, then, is the principle on which the inventions of Papin, the Marquis of Worcester, Newcomen, and James Watt have been based.

The great astronomer Huyghens conceived the idea of creating a motive machine by exploding a charge of gunpowder under a cylinder traversed by a piston: the air contained in this cylinder, dilated by the heat resulting from the combustion of the powder, escaped into the outer air through a valve, whereupon a partial void existed beneath the piston, or, rather, the air considerably rarified; and from this moment the pressure of the atmospheric air falling on the upper part of the piston, and being but imperfectly counterpoised by the rarified air beneath the piston, precipitated this piston to the bottom of the cylinder. Consequently, said Huyghens, if to the said piston were attached a chain or cord coiling around a pulley, one might raise up the weights placed at the extremity of the cord, and so produce a genuine mechanical effect.



GENERAL PRINCIPLE OF THE STEAM ENGINE.

But Experiment, the touchstone of Physical Truth, soon revealed the deficiencies of an apparatus such as Huyghens had suggested. The air beneath the piston was not sufficiently rarified; the void produced was too imperfect. Evidently gunpowder

was not the right agent. What was? Denis Papin answered, Steam. And the first Steam Engine ever invented was invented by this ingenious Frenchman.

Papin was born at Blois on the 22nd of August 1645. He died about 1714, but neither the exact date nor the place of his death is known. The lives of most men of genius are heavy with shadows, but Papin's career was more than ordinarily characterized by the incessant pursuit of the evil spirits of adversity and persecution. A Protestant, and devoutly loyal to his creed, he fled from France with thousands of his co-religionists, when Louis XIV. unwisely and unrighteously revoked the Edict of Nantes, which permitted the Huguenots to worship God after their own fashion. And it was abroad, in England, Italy, and Germany, that he realized the majority of his inventions, among which that of the Steam Engine is the most conspicuous.

In 1707 Papin constructed a steam engine on the principle we have already described, and placed it on board a boat provided with wheels. Embarking at Cassel on the river Fulda, he made his way to Münden in Hanover, with the design of entering the waters of the Weser, and thence repairing to England, to make known his discovery, and test its capabilities before the public. But the harsh and ignorant boatmen of the Weser would not permit him to enter the river; and when he indignantly

complained, they had the barbarity to break his boat in pieces. This was the crowning misfortune of Papin's life. Thenceforward he seems to have lost all heart and hope. He contrived to reach London, where the Royal Society, of which he was a member, allowed him a small pittance.

In 1690 this ingenious man had devised an engine in which atmospheric vapour instead of steam was the motive agent. At a later period, Newcomen, a native of Dartmouth in Devonshire, conceived the idea of employing the same source of power.

But, previously, the value of steam, if employed in this direction, had occurred to the Marquis of Worcester, a nobleman of great ability and a quick imagination, who, for his loyalty to the cause of Charles I., had been confined in the Tower of London as a prisoner. On one occasion, while sitting in his solitary chamber, the tight cover of a kettle full of boiling water was blown off before his eyes; for mere amusement's sake he set it on again, saw it again blown off, and then began to reflect on the capabilities of power thus accidentally revealed to him, and to speculate on its application to mechanical ends. Being of a quick, ingenious turn of mind, he was not long in discovering how it could be directed and controlled. When he published his project—"An Admirable and Most Forcible Way to Drive up Water by Fire"—he was abused

and laughed at as being either a madman or an impostor. He persevered, however, and actually had a little engine of some two horse power at work raising water from the Thames at Vauxhall; by means of which, he writes, "a child's force bringeth up a hundred feet high an incredible quantity of water, and I may boldly call it the most stupendous work in the whole world." There is a fervent "Ejaculatory and Extemporary Thanksgiving Prayer" of his extant, composed "when first with his corporeal eyes he did see finished a perfect trial of his water-commanding engine, delightful and useful to whomsoever hath in recommendation either knowledge, profit, or pleasure." This and the rest of his wonderful "Centenary of Inventions," only emptied instead of replenishing his purse. He was reduced to borrow paltry sums from his creditors, and received neither respect for his genius nor sympathy for his misfortunes. He was before his age, and suffered accordingly.

In 1698 his work was taken up by Thomas Savery, a miner, who, through assiduous labour and well-directed study, had become a skilful engineer. He succeeded in constructing an engine on the principle of the pressure of aqueous vapour, and this engine he employed successfully in pumping water out of coal mines. We owe to Savery the invention of a vacuum, which was suggested to him,

it is said, in a curious manner: he happened to throw a wine-flask, which he had just drained, upon the fire; a few drops of liquor at the bottom of the flask soon filled it with steam, and, taking it off the fire, he plunged it, mouth downwards, into a basin of cold water that was standing on the table, when, a vacuum being produced, the water immediately rushed up into the flask.

In tracing this lineage of inventive genius, we next come to Thomas Newcomen, a blacksmith, who carried out the principle of the piston in his Atmospheric Engine, for which he took out a patent in 1705. It is but just to recognize that this engine was the first which proved practically and widely useful, and was, in truth, the actual progenitor of the present steam engine. It was chiefly used for working pumps. To one end of a beam moving on a central axis was attached the rod of the pump to be worked; to the other, the rod of the piston moving in the cylinder below. Underneath this cylinder was a boiler, and the two were connected by a pipe provided with a stop-cock to regulate the supply of steam. When the pump-rod was depressed, and the piston raised to the top of the cylinder, which was effected by weights hanging to the pump-end of the beam, the stop-cock was used to cut off the steam, and a supply of cold water injected into the cylinder through a water-pipe connected with the tank or cistern. The steam in the cylinder was

immediately condensed; a vacuum created below the piston; the latter was then forced down by atmospheric pressure, bringing with it the end of the beam to which it was attached, and raising the other along with the pump-rod. A fresh supply of steam was admitted below the piston, which was raised by the counterpoise; and thus the motion was constantly renewed. The opening and shutting of the stop-cocks was at first managed by an attendant; but a boy named Potter, who was employed for this purpose, being fonder of play than work, contrived to save himself all trouble in the matter by fastening the handles with pieces of string to some of the cranks and levers. Subsequently, Beighton, an engineer, improved on this idea by substituting levers, acted on by pins in a rod suspended from the beam.

Properly speaking, Newcomen's engine was not a steam, but an atmospheric engine; for though steam was employed, it formed no essential feature of the contrivance, and might have been replaced by an air-pump. All the use that was made of steam was to produce a vacuum underneath the piston, which was pressed down by the weight of the atmosphere, and raised by the counterpoise of the buckets at the other end of the beam. Watt, in bringing the expansive force of steam to bear upon the working of the piston, may be said to have really invented the steam engine. Half a century before the little model came into Watt's hands, Newcomen's engine

had been made as complete as its capabilities admitted of; and Watt struck into an entirely new line, and invented an entirely new machine, when he produced his Condensing Engine.

II.—JAMES WATT.

There are few places in our country where human enterprise has effected such vast and marvellous changes within the century as the country traversed by the river Clyde. Where Glasgow now stretches far and wide, with its miles of swarming streets, its countless mills, and warehouses, and foundries, its busy ship-building yards, its harbour thronged with vessels of every size and clime, and its large and wealthy population, there was to be seen, a hundred years ago, only an insignificant little burgh, as dull and quiet as any rural market-town of our own day. There was a little quay at the Broomielaw, seldom used, and partly overgrown with broom. No boat over six tons' burden could get so high up the river, and the appearance of a masted vessel was almost an event. Tobacco was the chief trade of the town; and the tobacco merchants might be seen strutting about at the Cross in their scarlet cloaks, and looking down on the rest of the inhabitants, who got their livelihood, for the most part, by dealing in grindstones, coals, and fish—"Glasgow magistrates," as herrings are popularly called, being in as great repute then as now. There were but scanty means of intercourse

with other places, and what did exist were little used, except for goods, which were conveyed on the backs of pack-horses. The caravan then took two days to go to Edinburgh—you can run through now between the two cities in little more than an hour. There is hardly any trade that Glasgow does not prosecute vigorously and successfully. You may see any day you walk down to the Broomielaw, vessels of a thousand tons' burden at anchor there, and the custom duties which were in 1796 little over £100, have now reached an amount exceeding one million!

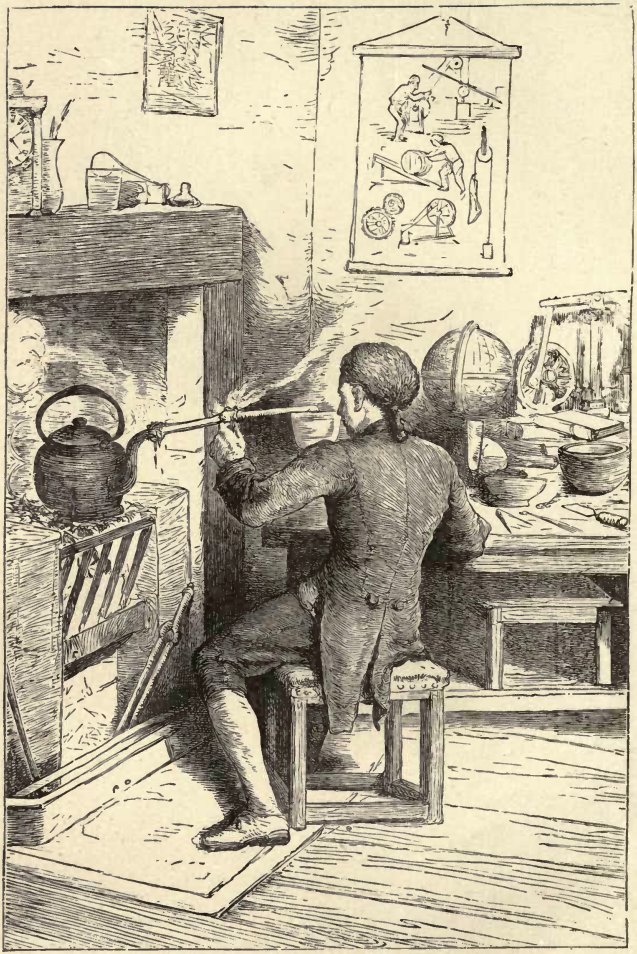
Glasgow is indebted, in a great part, for the gigantic strides which it has made, to the genius, patience, and perseverance of a man who, in his boyhood, rather more than a hundred years ago, used to be scolded by his aunt for wasting his time, taking off the lid of the kettle, putting it on again, holding now a cup, now a silver spoon over the steam as it rose from the spout, and catching and counting the drops of water it fell into. James Watt was then taking his first elementary lessons in that science, his practical application of which in after life was to revolutionize the whole system of mechanical movement, and place an almost unlimited power at the disposal of the industrial classes.

When a boy, James Watt was delicate and sickly, and so shy and sensitive that his school-days were a misery to him, and he profited but little by his attendance. At home, though, he was a great reader.

and picked up a great deal of knowledge for himself, rarely possessed by those of his years. One day a friend was urging his father to send James to school, and not allow him to trifle away his time at home, "Look how the boy is occupied," said his father, "before you condemn him." Though only six years old, he was trying to solve a geometrical problem on the floor with a bit of chalk. As he grew older he took to the study of optics and astronomy, his curiosity being excited by the quadrants and other instruments in his father's shop. By the age of fifteen he had twice gone through De Gravesande's Elements of Natural Philosophy, and he was also well versed in physiology, botany, mineralogy, and antiquarian lore. He was further an expert hand in using the tools in his father's workshop, and could do both carpentry and metal work. After a brief stay with an old mechanic in Glasgow, who, though he dignified himself with the name of "optician," never rose beyond mending spectacles, tuning spinets, and making fiddles and fishing tackle, Watt went at the age of eighteen to London, where he worked so hard, and lived so sparingly in order to relieve his father from the burden of maintaining him, that his health suffered, and he had to recruit it by a return to his native air. During the year spent in the metropolis, however, he managed to learn nearly all that the members of the trade there could teach, and soon showed himself a quick and skilful workman.

In 1757 we find the sign of "James Watt, Mathematical Instrument Maker to the College," stuck up over the entrance to one of the stairs in the quadrangle of Glasgow College. But though under the patronage of the University, his trade was so poor, that thrifty and frugal as he was, he had a hard struggle to live by it. He was ready, however, for any work that came to hand, and would never let a job go past him. To execute an order for an organ which he accepted, he studied harmonics diligently, and though without any ear for music, turned out a capital instrument, with several improvements of his own in its action; and he also undertook the manufacture of guitars, violins, and flutes. All this while he was laying up vast stores of knowledge on all sorts of subjects, civil and military engineering, natural history, languages, literature, and art; and among the professors and students who dropped into his little shop to have a chat with him, he soon came to be regarded as one of the ablest men about the college, while his modesty, candour, and obliging disposition gained him many good friends.

Among his multifarious pursuits, Watt had experimented a little in the powers of steam; but it was not till the winter of 1763–4, when a model of Newcomen's engine was put into his hands for repair, that he took up the matter in earnest. Newcomen's engine was then about the most complete invention of its kind; but its only value was its power of pro-



JAMES WATT.

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ducing a ready vacuum, by rapid condensation on the application of cold; and for practical purposes was neither cheaper nor quicker than animal power. Watt, having repaired the model, found, on setting it agoing, that it would not work satisfactorily. Had it been only a little less clumsy and imperfect, Watt might never have regarded it as more than the "fine plaything," for which he at first took it; but now the difficulties of the task roused him to further efforts. He consulted all the books he could get on the subject, to ascertain how the defects could be remedied; and that source of information exhausted, he commenced a series of experiments, and resolved to work out the problem for himself. Among other experiments, he constructed a boiler which showed by inspection the quantity of water evaporated in a given time, and thereby ascertained the quantity of steam used in every stroke of the engine. He found, to his astonishment, that a small quantity of water in the form of steam heated a large quantity of water injected into the cylinder for the purpose of cooling it; and upon further examination, he ascertained the steam heated six times its weight of well water up to the temperature of the steam itself (212°). After various ineffectual schemes, Watt was forced to the conclusion that, to make a perfect steam engine, two apparently incompatible conditions must be fulfilled—the cylinder must always be as hot as the steam that came rushing into it, and yet, at each

descent of the piston, the cylinder must become sufficiently cold to condense the steam. He was at his wit's end how to accomplish this task, when, as he was taking a walk one afternoon, the idea flashed across his mind that, as steam was an elastic vapour, it would expand and rush into a previously exhausted place; and that, therefore, all he had to do to meet the conditions he had laid down, was to produce a vacuum in a separate vessel, and open a communication between this vessel and the cylinder of the steam-engine at the moment when the piston was required to descend, and the steam would disseminate itself and become divided between the cylinder and the adjoining vessel. But as this vessel would be kept cold by an injection of water, the steam would be annihilated as fast as it entered, which would cause a fresh outflow of the remaining steam in the cylinder, till nearly the whole of it was condensed, without the cylinder itself being chilled in the operation. Here was the great key to the problem; and when once the idea of separate condensation was started, many other subordinate improvements, as he said himself, "followed as corollaries in rapid succession, so that in the course of one or two days the invention was thus far complete in his mind."

It cost him ten long weary years of patient speculation and experiment, to carry out the idea, with little hope to buoy him up, for to the last he used to say "his fear was always equal to his hope,"—

and with all the cares and embarrassments of his precarious trade to perplex and burden him. Even when he had his working model fairly completed, his worst difficulties—the difficulties which most distressed and harassed the shy, sensitive, and retiring Watt—seemed only to have commenced. To give the invention a fair practical trial required an outlay of at least £1000; and one capitalist, who had agreed to join him in the undertaking, had to give it up through some business losses. Still Watt toiled on, always keeping the great object in view,—earning bread for his family (for he was married by this time), by adding land-surveying to his mechanical labours, and, in short, turning his willing hand to any honest job that offered.

He got a patent in 1769, and began building a large engine; but the workmen were new to the task, and when completed, its action was spasmodic and unsatisfactory. "It is a sad thing," he then wrote, "for a man to have his all hanging by a single string. If I had wherewithal to pay for the loss, I don't think I should so much fear a failure; but I cannot bear the thought of other people becoming losers by my scheme, and I have the happy disposition of always painting the worst." And just then, to make matters still more gloomy, he learned that some rascally linen-draper in London was plagiarizing the great invention he had brought forth in such sore and protracted travail. "Of all things

in the world," cried poor Watt, sick with hope deferred, and pressed with little carking cares on every side, "there is nothing so foolish as inventing."

When nearly giving way to despair, and on the point of abandoning his invention, Watt was fortunate enough to fall in with Matthew Boulton, one of the great manufacturing potentates of Birmingham, an energetic, far-seeing man, who threw himself into the enterprise with all his spirit; and the fortune of the invention was made. An engine, on the new principle, was set up at Soho; and there Boulton and Watt sold, as the former said to Boswell, "what all the world desires to have, POWER;"—the infinite power that animates those mighty engines, which—

> "England's arms of conquest are,
> The trophies of her bloodless war:
> Brave weapons these.
> Victorious over wave and soil,
> With these she sails, she weaves, she tills,
> Pierces the everlasting hills,
> And spans the seas."

Watt's engine, once fairly started, was not long in making its way into general use. The first steam-engine used in Manchester was erected in 1790; and now it is estimated that in that district, within a radius of ten miles, there are in constant work more than fifty thousand boilers, giving a total power of upwards of one million horses. And the united steam power of Great Britain is considered equal to the manual labour of upwards of four hundred millions of men, or more than double the number of males on

the face of the earth. From the factory at Soho, Watt's improved engines were dispersed all over the country, especially in Cornwall—the firm receiving the value of a third part of the coal saved by the use of the new machine. In one mine, where there were three pumps at work, the proprietors thought it worth while, it is said, to purchase the rights of the inventors, at the price of £2500 yearly for each engine. The saving, therefore, on the three engines, in fuel alone, must have been at least £7500 a year.

In the first year of the present century, Watt withdrew himself entirely from business; but though he lived in retirement, he did not let his busy mind get rusty or sluggish for want of exercise. At one time he took it into his head that his faculties were declining, and though upwards of seventy years of age, he resolved to test his mental powers by taking up some new subject of study. It was no easy matter to find one quite new to him, so wide and comprehensive had been his range of study; but at length the Anglo-Saxon tongue occurred to him, and he immediately applied himself to master it, the facility with which he did so, dispelling all doubt as to the failing of his stupendous intellect. He thus busied himself in various useful and entertaining pursuits, till close upon his death, which took place in 1819.

Extraordinary as was Watt's inventive genius, his wide range of knowledge, theoretic and practical, was equally so. Great as is the "idea" with which his

name is chiefly associated, he was not a man of one idea, but of a thousand. There was hardly a subject which came under his notice which he did not master; and, as was said of him, "it seemed as if every subject casually started by him had been that he had been occupied in studying." He had no doubt a rapid faculty of acquiring knowledge; but he owed the versatility and copiousness of his attainments above all to his unwearied industry. He was always at work on something or other, and he may truly be called one of those who—

> "Could Time's hour-glass fall,
> Would, as for seed of stars, stoop for the sand,
> And by incessant labour gather all."

In a recent volume of memoirs by Mrs. Schimmel Pennick, we find the following graphic sketch of this extraordinary man:—"He was one of the most complete specimens of the melancholic temperament. His head was generally bent forward or leaning on his hand in meditation, his shoulders stooping, and his chest falling in, his limbs lank and unmuscular, and his complexion sallow. His utterance was slow and impassioned, deep and low in tone, with a broad Scotch accent; his manners gentle, modest, and unassuming. In a company where he was not known, unless spoken to, he might have tranquilly passed the whole time in pursuing his own meditations. When he entered the room, men of letters, men of science, many military men, artists, ladies, and even

little children, thronged around him. I remember a celebrated Swedish artist being instructed by him that rat's whiskers made the most pliant painting-brushes; ladies would appeal to him on the best modes of devising grates, curing smoking chimneys, warming their houses, and obtaining fast colours."

His reading was singularly extensive and diversified. He perused almost every work that came in his way, and used to say that he never opened a book, no matter what its subject or worth, without learning something from it. He had a vivid imagination, was passionately fond of fiction, and was a very gifted story-teller himself. When a boy, staying with his aunt in Glasgow, he used every night to enthral the attention of the little circle with some exciting narrative, which they would not go to bed till they had heard the end of; and kept them in such a state of tremor and excitement, that his aunt used to threaten to send him away.

Since Watt's time, innumerable patents have been taken out for improvements in the steam engine; but his great invention forms the basis of nearly all of them, and the alterations refer rather to details than principles of action. The application of steam to locomotive purposes, however, led to the construction of the high pressure engine, in which the cumbrous condensing apparatus is dispensed with, and motion imparted to the piston by the elastic power of the steam being greater than that of the atmosphere.

The Manufacture of Cotton.

I.—KAY AND HARGREAVES.
II.—SIR RICHARD ARKWRIGHT.
III.—SAMUEL CROMPTON.
IV.—DR. CARTWRIGHT.
V.—SIR ROBERT PEEL.

The Manufacture of Cotton.

"Are not our greatest men as good as lost? The men who walk daily among us, clothing us, warming us, feeding us, walk shrouded in darkness, mere mythic men."—CARLYLE.

I.—KAY AND HARGREAVES.

ON the 3d of May 1734, there was a hanging at Cork which made a good deal more noise than such a very ordinary event generally did in those days. There was nothing remarkable about the malefactor, or the crime he had committed. He was a very commonplace ruffian, and had earned his elevation to the gallows by a vulgar felony. What was remarkable about the affair was, that the woollen weavers of Cork, being then in a state of great distress from want of work, dressed up the convict in cotton garments, and that the poor wretch, having once been a weaver himself, "employed" the last occasion he was ever to have of addressing his fellow creatures, by assuring them that all his misdeeds and misfortunes were to be traced to the "pernicious practice of wearing cottons." "Therefore, good Christians," he continued, "consider that if you go on to suppress your own goods, by wearing such cottons as I am now clothed in, you will bring your country into misery, which will consequently swarm with such

unhappy malefactors as your present Object is; and the blood of every miserable felon that will hang after this warning from the gallows will lie at your doors."

All which sayings were no doubt greatly applauded by the disheartened weavers on the spot, and much taken to heart by the citizens and gentry to whom they were addressed.

This is only one out of the many illustrations which might be drawn from the chronicles of those days, of the prejudice and discouragement cotton had to contend against on its first appearance in this country. Prohibited over and over again, laid under penalties and high duties, treated with every sort of contumely and oppression, it had long to struggle desperately for the barest tolerance; yet it ended by overcoming all obstacles, and distancing its favoured rival wool. Returning good for evil, cotton now sustains one-sixth of our fellow-countrymen, and is an important mainstay of our commerce and manufactures.

First imported into Great Britain towards the middle of the seventeenth century, cotton was but little used for purposes of manufacture till the middle of the eighteenth. The settlement of some Flemish emigrants in Lancashire led to that district becoming the principal seat of the cotton manufacture; and probably the ungenerous nature of its soil induced the people to resort to spinning and weaving

to make up for the unprofitableness of their agricultural labours.

A nobler monument of human skill, enterprise, and perseverance, than the invention of cotton-spinning machinery is hardly to be met with; but it must also be owned that its history, encouraging as it is in one aspect, is in another sad and humiliating to the last degree. It is difficult at first to credit the uniform ingratitude and treachery which the various inventors met with from the very men whom their contrivances enriched. "There is nothing," said James Watt in the crisis of his fortunes, worn with care, and sick with hope deferred—"there is nothing so foolish as inventing;" and with far more reason the inventors of cotton-spinning machines could echo the mournful cry. It is sad to think that so proud a chapter of our history should bear so dark a stain.

In 1733 the primitive method still prevailed of spinning between the finger and thumb, only one thread at a time; and weaving up the yarn in a loom, the shuttle of which had to be thrown from right to left and left to right by both hands alternately. In that year, however, the first step was made in advance, by the invention of the fly-shuttle, which, by means of a handle and spring, could be jerked from side to side with one hand. This contrivance was due to the ingenuity of John Kay, a loom-maker at Colchester, and proved his ruin. The

weavers did their best to prevent the use of the shuttle,—the masters to get it used, and to cheat the inventor out of his reward. Poor Kay was soon brought low in the world by costly law-suits, and being not yet tired of inventing, devised a rude power-loom. In revenge a mob of weavers broke into his house, smashed all his machines, and would have smashed him too, had they laid hands on him. He escaped from their clutches, to find his way to Paris, and to die there in misery not long afterwards. Kay was the first of the martyrs in this branch of invention. James Hargreaves was the next.

The use of the fly-shuttle greatly expedited the process of weaving, and the spinning of cotton soon fell behind. The weavers were often brought to a stand-still for want of weft to go on with, and had to spend their mornings going about in search of it, sometimes without getting as much as kept them busy for the rest of the day. The scarcity of yarn was a constant complaint; and many a busy brain was at work trying to devise some improvement on the common hand-wheel. Amongst others, James Hargreaves, an ingenious weaver at Standhill, near Blackburn, who had already improved the mode of cleaning and unravelling the cotton before spinning, took the subject into consideration. One day, when brooding over it in his cottage, idle for want of weft, the accidental overturning of his wife's wheel suggested to him the principle of the spinning-jenny.

Lying on its side, the wheel still continued in motion —the spindle being thrown from a horizontal into an upright position; and it occurred to him that all he had got to do was to place a number of spindles side by side. This was in 1764, and three years afterwards Hargreaves had worked out the idea, and constructed a spinning frame, with eight spindles and a horizontal wheel, which he christened after his wife Jenny, whose wheel had first put him in the right track. Directly the spinners of the locality got knowledge of this machine that was to do eight times as much as any one of them, they broke into the inventor's cottage, destroyed the jenny, and compelled him to fly for the safety of his life to Nottingham. He took out a patent, but the manufacturers leagued themselves against them. Sole, friendless, penniless, he could make no head against their numbers and influence, relinquished his invention, and died in obscurity and distress ten years after he had the misfortune to contrive the spinning-jenny.

The history of the cotton manufacture now becomes identified with the lives of Arkwright, Crompton, and Cartwright—the inventors of the water-frame, the mule, and the power-loom.

II.—SIR RICHARD ARKWRIGHT.

Somewhere about the year 1752, any one passing along a certain obscure alley in Preston, then a mere village compared with the prosperous town into

which it has since expanded, might have observed projecting from the entrance to the underground flat of one of the houses, a blue and white pole, with a battered tin plate dangling at the end of it, the object of which was to indicate that if he wanted his hair cut or his chin shaved, he had only to step down stairs, and the owner of the sign would be delighted to accommodate him. But either people in that quarter had little or no superfluous hair to get rid of, or they had it taken off elsewhere; for Dicky Arkwright, the barber in the cellar, for whom the pole and plate stood sponsor in the upper world, had few opportunities of displaying his talents, and spent most of his time whetting his razors on a long piece of leather, one end of which was nailed to the wall, while the other was drawn towards him, and keeping the hot water and the soap ready for the customers who seldom or never came. This sort of thing did not suit Dick's notions at all; for he was of an active temperament, and besides feeling very dull at being so much by himself all day, he pulled rather a long face when he counted out the scanty array of coppers in the till after shutting up shop for the night. As he sat one night, before tumbling into his truckle bed that stood in a recess in one corner of the dingy little room, meditating on the hardness of the times, a bright idea struck him; and the next morning the attractions of the sign-pole were enhanced by a staring placard, bearing the urgent invitation:—

COME TO THE

SUBTERRANEOUS BARBER!

HE SHAVES FOR A PENNY!!

Now twopence, as we believe all those who have investigated the subject are agreed, was the standard charge for a clean shave at that period; and as soon as this innovation got wind, we can fancy how indignant the fraternity were at the unprincipled conduct of one of their number; how they denounced the reprobate, and prophesied his speedy ruin, over their pipes and beer in the parlour of the "Duke of Marlborough," which they patronized out of respect for that hero's enormous periwig,—in their eyes his chief title to immortality, and a bright example for the degenerate age, when people had not only taken to wearing their own hair, but were even beginning to leave off dusting it with flour! And to make matters worse, here was a low fellow offering to shave for a penny. A number of people, tickled with the originality of the placard, and not unmindful of the penny saved, began to patronize the "Subterraneous barber," and he soon drew so many customers away from the higher-priced shops, that they were obliged to come down, after a while, to a penny as well. Not to be outdone, Arkwright lowered his charge to a halfpenny, and still retained his rank as the cheapest barber in the place.

Arkwright's parents had been very poor people;

and as he was the youngest of a family of thirteen, it may be readily supposed that all the school learning he got was of the most meagre kind,—if, indeed, he ever was at school at all, which is very doubtful. He was of a very ardent, enterprising temperament, however, and when once he took a thing in hand, stubbornly persevered in carrying it through to the end. About the year 1760, being then about thirty years of age, Arkwright got tired of the shaving, which brought him but a very scanty and precarious livelihood, and resolved to try his luck in a business where there was more scope for his enterprise and activity. He therefore began business as an itinerant dealer in hair, travelling up and down the country to collect it, dressing it himself, and then disposing of it in a prepared state to the wig-makers. As he was very quick in detecting any improvements that might be made in the process of dressing, he soon acquired the reputation amongst the wig-makers of supplying a better article than any of his rivals, and drove a very good trade. He had also picked up or discovered for himself the secret of dyeing the hair in a particular way, by which he not only augmented his profits, but enlarged the circle of his customers. He throve so well, that he was able to lay by a little money and to marry. He was very fond of spending what leisure time he had in making experiments in mechanics; and for a while was very much taken up with an attempt to solve the attractive problem

of perpetual motion. No doubt he soon saw the hopelessness of the effort; but although he left the question unsolved, the bent thus given to his thoughts was fruitful of most valuable consequences.

Living in the midst of a manufacturing population, Arkwright was accustomed to hear daily complaints of the continual difficulty of procuring sufficient weft to keep the looms employed; while the exportation of cotton goods gave rise to a growing demand for the manufactured article. The weavers generally had the weft they used spun for them by their wives or daughters; and those whose families could not supply the necessary quantity, had their spinning done by their neighbours; and even by paying, as they had to do, more for the spinning than the price allowed by their masters, very few could procure weft enough to keep themselves constantly at work. It was no uncommon thing, we learn, for a weaver to walk three or four miles in a morning, and call on five or six spinners, before he could collect weft to serve him for the rest of the day. Arkwright must have been constantly hearing of this difficulty, and of the restrictions it placed on the manufacture of cotton goods; and being a mechanical genius, was led to think how it might be lessened, if not got rid of altogether. The idea of having an automaton spinner, instead of one of flesh and blood, had occurred before then to more than one speculator; but the thing had never answered, and no models or descrip-

tions of the machines proposed were preserved. One inventor had, indeed, destroyed his own machine, after having constructed it and found it to work, for fear that if it came into use it would deprive the poor spinners of their livelihood,—in reality its effect would have been to provide employment and food for thousands more than at that time got a miserable living from their spinning-wheels.

While Arkwright was intent on the discovery of perpetual motion, he fell in with a clockmaker of the name of Kay, who assisted him in making wheels and springs for the contrivance he was trying to complete. This led to an intimate connection between them; and when Arkwright had given up the perpetual motion affair, and applied his thoughts to the invention of some machine for producing cotton weft more rapidly than by the simple wheel, Kay continued to help him in making models. Arkwright soon became so engrossed in his new task, and so confident of ultimate success, that he began to neglect his regular business. All his thoughts, and nearly all his time, were given up to the great work he had taken in hand. His trade fell off; he spent all his savings in purchasing materials for models, and getting them put together, and he fell into very distressed circumstances. His wife remonstrated with him, but in vain; and one day, in a rage at what she considered the cause of all their privations, she smashed some of his models on the floor. Such an

outrage was more than Arkwright could bear, and they separated.

In 1768, Arkwright, having completed the model of a machine for spinning cotton thread, removed to Preston, taking Kay with him. At this time he had hardly a penny in the world, and was almost in rags. His poverty, indeed, was such, that soon after his arrival in Preston, a contested election for a member of Parliament having taken place, he was so tattered and miserable in his appearance, that the party with whom he voted had to give him a decent suit of clothes before he could be seen at the polling-booth. He had got leave to set up his machine in the dwelling-house attached to the Free Grammar School; but, afraid of suffering from the hostility of the spinners, as the unfortunate Hargreaves had done some time before, he and Kay thought it best to leave Lancashire, and try their fortune in Nottingham.

Poor and friendless, it may easily be supposed that Arkwright found it a hard matter to get any one to back him in a speculation which people then regarded as hazardous, if not illusory. He got a few pounds from one of the bankers in the town; but that was soon spent, and further advances were refused. Nothing daunted, Arkwright tried elsewhere for help, and at length succeeded in convincing Messrs. Need and Strutt,* large stocking-weavers in the

* The founder of the family of Strutt of Belper, afterwards ennobled.

place, of the value of his invention, and inducing them to enter into partnership with him. In 1769 he took out a patent for the machine, as its inventor, and a mill, worked by horse-power, was erected for spinning cotton by the new machine. Two years after, he and his partner set up another mill in Derbyshire, worked by a water-wheel; and in 1775 he took out another patent for some improvements on his original scheme.

The machinery which he patented consisted of a number of different contrivances; but the chief of these, and the one which he particularly claimed entirely as his own invention (for he frankly admitted that some of the other parts were only developments of other inventors), was what is called the water-frame throstle for drawing out the cotton from a coarse to a finer and harder twisted thread, and so rendering it fit to be used for the warp, or longitudinal threads of the cloth, which were formed of linen, as well as the weft. This apparatus was a combination of the carding and spinning machinery; and the principle of having two pairs of rollers, one revolving faster than the other, was now for the first time applied to machinery.

In a year or two the success of Arkwright's inventions was fairly established. The manufacturers were fully alive to its importance; and Arkwright now reaped the reward of all the toil and danger he had undergone in the shape of a diligent and per-

sistent attempt to rob him of his monopoly, which was carried on for a number of years, and was at length successful. Some of the manufacturers, who were greedy to profit by the new machinery without paying the inventor, got hold of Kay, who had quarrelled with Arkwright some time before, and found him a willing instrument in their hands. It would take too long to go over all the law processes which Arkwright had now to engage in to defend his rights. Kay got up a story that the real inventor was a poor reed maker named Highs, who had once employed him to make a model, the secret of which he had imparted to Arkwright; and this was a capital excuse for using the new machinery in defiance of the patent, although the evidence at the various trials is now held completely to vindicate Arkwright's title as inventor. One law plea was lost to him, on account of some technical omission in the specifications; another restored to him the enjoyment of his monopoly; and a third trial destroyed the patent, which Arkwright never took any steps to recover.

Besides trying to defraud Arkwright of his patent-rights, the rival manufacturers, with jealous inconsistency, did their best to discountenance the use of the yarns he made, although much superior in quality to what was then in use. But Arkwright not only surmounted this obstacle, but turned it to good account, for it set him to manufacturing the yarn into stockings and calicoes, the duty on which being

soon after lowered, in spite of the strenuous opposition of the manufacturers, turned out a very profitable speculation.

For the first five years Arkwright's mills yielded little or no profit; but after that, the adverse tide against which he had struggled so bravely changed, and he followed a prosperous and honourable career till his death, which happened in 1792. He was knighted, not for being, as he was, a benefactor to his country, but because, in his capacity of high sheriff, he chanced to read some trumpery address to the king. He left behind a fortune of about half a million sterling.

III.—SAMUEL CROMPTON.

Excellent as was the yarn produced by the spinning-jenny and the water-frame, compared with the old hand-spun stuff, it was coarse and full of knots; and when a demand arose for imitations of the fine India muslins, the weavers found they could produce but a very poor piece of work with such rough materials.

Among those who were inconvenienced for want of a better sort of yarn was young Samuel Crompton, who lived with his widowed mother and two sisters in an old country house called Hall-in-the-Wood, near what was then the little rural town of Bolton in the Moors. When Samuel was only five years old his father died, and left his widow with the three chil-

dren on her hands, to struggle through the world as best she could. A hard-working, energetic, God-fearing woman, she buckled to the fight with a stout heart and a resolute will. Her husband had been both farmer and weaver, like most of the men in that quarter; and she did her best to fill his place, looking after the little farm and the three cows, and working at the loom, the yarn for which she taught the bairns to spin. Whatever she took in hand she did with might and main, and the result was, her webs were the best woven, her butter the richest, her honey the purest, her home-made wines the finest flavoured of any in the district. Small as her means were, she gave her boy the best education that could be got in Bolton—first at a day-school, and afterwards, when he was old enough to take his place by day between the treadles, at a night-school. Rigid in her sense of duty, and resolute to do her own share of the work, she exacted the same from others, and kept her lad tightly to the loom. Every day he had to do a certain quantity of work; and there was no looking her in the face unless each evening saw it done, and well done too. Anxious to satisfy his mother, and yet get time for his favourite amusement of fiddle-making and fiddle-playing, Sam grew quickly sensitive of the imperfections of the machinery he had to work with. "He was plagued to deeath," he used to say, "wi' mendin' the broken threeads;" and could not help thinking many a time whether

the jenny could not be improved so as to spin more quickly, and produce a better thread. By the time he came to man's estate, in 1774, his thoughts had settled so far into a track, that he was able to begin making a contrivance of his own, which he hoped would accomplish the object he had in view. He had a few common tools which had belonged to his father, but his own clasp-knife served nearly every purpose in his ready hands. He had his "bits of things" filed at the smithy, and to get money for materials, he fiddled at the theatre for 1s. 6d. a night. Every minute he could spare from the task-work of the day was spent in his little room over the porch of the hall in forwarding his invention. As it advanced, he grew more and more engrossed with it, and often the dawn found him still at work on it. The good folks down in Bolton were sorely puzzled to think what light it was that was so often seen glimmering at uncanny hours up at the old hall. The story went abroad that the place was haunted, and that the ghost of some former resident, uneasy from the sorrows or the sins of his past life, kept watch and ward till cock crow, with a spectral lamp. The mystery was cleared up at last. It was discovered that the ghost was only Sam Crompton "fashing himself over bits of wood and iron;" and Sam was pointed out as a "conjuror"—the cant term for inventor—when he walked through the town.

The five years of labour and anxiety bore fruit in

1779, when the "mule-jenny" with its spindle carriage was finished and set to work. As its name indicates, it was an ingenious cross between the jenny and the water-frame, combining the best features of both with several novel ones, which rendered it a very valuable machine.

Just as Crompton had put the finishing touches to his mule, the weavers and spinners broke out in open riot at Blackburn, and scoured the country with the cry, "Men, not machines;" breaking every machine they could lay hands on. To keep himself out of trouble and save his mule, Crompton took it to pieces, and hid it in the roof of the hall. When the storm had swept past, he brought it out, put it together, and began to use it in his daily work. The fine yarn he turned out made quite a sensation, and the fame of his invention spread far and wide. People came from all quarters to get a sight of it; and when denied admittance, brought ladders and harrows, and climbed up to the window of the room where it stood. One pertinacious fellow actually ensconced himself for several days in the cockloft, from which he watched Crompton at work in the room below, through a gimlet hole he bored in the ceiling. Crompton lost all patience with this constant espionage. "Why couldn't folk let him enjoy his machine by himself?" he asked. A friend, whose advice he asked, urged him not to think of taking out a patent, but to make a present of his invention to the com-

munity at large. Save me from my friends, Crompton might well have cried. Simple, guileless fellow that he was, he acted on his "friend's" advice, and on a number of manufacturers putting down their names for subscriptions varying from a guinea to a crown, threw open the invention to the world. When the time came for the subscriptions to be called in, some of the manufacturers actually were base enough to refuse payment of the paltry sums they had promised, and overwhelmed with abuse the man by the fruit of whose brain they were making their fortunes. When all the money was collected, it amounted to only £60, just as much as built Crompton a new machine, with no more than four spindles.

Shy, simple, confiding, innocent of the cunning ways of the world, sadly backward in the study of mankind, and perhaps somewhat ungenial and unpractised to boot, Crompton, from the time when one would have thought he had set his foot on the first round of the ladder of fortune, went stumbling on from one misfortune to another, ill-used on every side, and unsuccessful in every effort to get on in the world. Wheedled out of his patent rights, cheated of the money promised him, his workmen lured away from him as soon as he had taught them the construction of the mule, he grew morbid and distrustful of every one. He would have no more workmen; and as the production of his machines was thus restricted to the labours of his own hands, he could

not compete with the large factories, who drew all the customers away from him. Peel, the father of the statesman, offered him first a lucrative place of trust, and afterwards a partnership ; but he would not listen to him. He grew more wretched and discouraged every day. In despair he cut up his spinning machines, and hacked to pieces with an axe a carding machine he had invented, exclaiming bitterly, "They shall not have this too."

He then retired into comparative obscurity at Oldham, where he drudged away at weaving, farming, cow-keeping, and overseeing the poor, and found it no easy matter withal to support his family, for he had married some years before. Afterwards he re-appeared at Bolton as a small manufacturer ; and there was a brief interval of sunshine. The muslin trade was very brisk, and the weavers walked about with five-pound notes stuck in their hats, and dressed out in ruffled shirts and top boots, like fine gentlemen. While this lasted Crompton found abundant sale for his superior yarn. But trade grew depressed, and the gloom settled over Crompton's life to its close.

The idea was started of getting Parliament to do something for him ; but he was too independent to supplicate government officials in person. Spencer Perceval, the Chancellor of the Exchequer, was willing to befriend him ; but Crompton's ill luck was at his heels. On the 11th of May 1812, Crompton

was talking with Peel and another gentleman in the lobby of the House of Commons, when Perceval walked up to them, saying, "You will be glad to know we mean to propose £20,000 for Crompton. Do you think it will be satisfactory?" Crompton walked away out of delicacy not to hear the answer. An instant afterwards there was a great shout, and a rush of people in alarm. Perceval lay bathed in his own blood, slain by the bullet of the assassin Bellingham. Crompton had lost his friend.

When the subject of a grant to the inventor of the spinning-mule was brought up in the House a few days afterwards by Lord Stanley (now Lord Derby), only £5000 was proposed. No one thought of increasing it. "Let's give the man a £100 a-year," said an honourable member; "it's as much as he can drink." So the vote was agreed to; though at that very time the duty accruing to the revenue from the cotton wool imported to be spun upon the mule was £300,000 a-year, or more than £1000 a working day. The impulse which this invention gave to the cotton manufactures of Great Britain, and the commercial prosperity to which it led, enabled the country to bear the heavy drain of the war taxes; and it has been said, with no little truth, that Crompton contributed as much as Wellington to the downfall of Napoleon. As soon as it became known, the mule-spindle took the lead in cotton-spinning machines. In 1811 above 4,600,000 mule-spindles, made by

his pattern, were in use. At the present time it is calculated that there are upwards of 30,000,000 in use in Great Britain; and the increase goes on at the rate of above 1,000,000 a-year. In France there were in 1850 about 3,000,000 spindles on Crompton's principle; and one firm of mule makers (Hibbert, Platt, and Company, of Oldham), make mules at the rate of 500,000 spindles a-year. The immense impetus given to trade, money, civilization, and comfort by this invention is almost incalculable.

The grant of £5000 was soon swallowed up in the payment of his debts, and in meeting the losses of his business. "Nothing more was ever done for him. The king, who was fond of patronizing merit, took no notice of him; his eldest son was promised a commission, which he did not get; and some time after, when struggling through life on only £100 a-year, the post of sub-inspector of the factories in Bolton became vacant; though he applied for the office, for which he was eminently qualified, he was passed over in favour of the natural son of one of the ex-secretaries of state—a man who did not know a mule from a spinning-jenny."*

Crompton spent his last days in poverty and privation, and died at the age of seventy-four, in 1827.

* Athenæum.

IV.—DR. CARTWRIGHT.

In the summer of 1784 a number of gentlemen were chatting, after dinner, in a country house at Matlock in Derbyshire. Some extensive cotton-mills had recently been set up in the neighbourhood, and the conversation turned upon the wonderful inventions which had been introduced for spinning cotton. There were one or two gentlemen present connected with the "manufacturing interest," who were very bitter against Arkwright and his schemes.

"It's all very well," said one of the grumblers, "but what will all this rapid production of yarn lead to? Putting aside the ruin of the poor spinners, who will be starved because they haven't as many arms as these terrible machines, you'll find that it will end in a great deal more yarn being spun than can be woven into cloth, and in large quantities of yarn being exported to the Continent, where it will be worked up by foreign weavers, to the injury of our home manufacture. That will be the short and the long of it, mark my words."

"Well, but, sir," remarked a grave, portly, middle-aged gentleman of clerical appearance, after a few minutes' reflection, "when you talk of the impossibility of the weaving keeping up with the spinning, you forget that machinery may yet be applied to the former as well as the latter. Why may there not be a loom contrived for working up yarn as fast as

the spindle produces it. That long-headed fellow Arkwright must just set about inventing a weaving machine."

"Stuff and nonsense," returned the "practical man" pettishly, as though it were hardly worth while noticing the remarks of such a dreamer. "You might as well bid Arkwright grow the cloth ready made. Weaving by machinery is utterly impossible. You must remember how much more complex a process it is than spinning, and what a variety of movements it involves. Weaving by machinery is a mere idle vision, my dear sir, and shows you know nothing about the operation."

"Well, I must confess my ignorance on the subject of weaving," replied the clergyman; "but surely it can't be a more complex matter than moving the pieces in a game of chess. Now, there's an automaton figure now exhibiting in London, which handles the chess men, and places them on the proper squares of the board, and makes the most intricate moves, for all the world as if it were alive. If that can be done, I don't see why weaving should baffle a clever mechanist. A few years ago we should have laughed at the notion of doing what Arkwright has done; and I'm certain that before many years are over, we shall have 'weaving Johnnies,' as well as 'spinning Jennies.'"

Dr. Cartwright, for that was the clergyman's name, confidently as he foretold that machine-weaving

would be devised before long, little dreamt at that moment that he was himself to bring about the fulfilment of his own prediction. A quiet, country clergyman, of literary tastes, a scholar, and poetaster, he had spent his life hitherto in the discharge of his ministerial duties, writing articles and verses, and had never given the slightest attention to mechanics, theoretical or practical. He had never so much as seen a loom at work, and had not the remotest notion of the principle or mode of its construction. But the chance conversation at the Matlock dinner table suddenly roused his interest in the subject. He walked home meditating on what sort of a process weaving must be; brooded over the subject for days and weeks,—was often observed by his family striding up and down the room in a fit of abstraction, throwing his arms from side to side like a weaver jerking the shuttles,—and at last succeeded in evolving, as the Germans would say, from "the depths of his moral consciousness," the idea of a power-loom. With the help of a smith and a carpenter, he set about the construction of a number of experimental machines, and at length, after five or six months' application, turned out a rude, clumsy piece of work, which was the basis of his invention.

"The warp," he says, "was laid perpendicularly, the reed fell with the force of at least half a hundredweight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket.

In short, it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself of what I then saw, I made a loom in its general principles nearly as they are now made. But it was not till the year 1787 that I completed my invention."

Having given himself to the contrivance of a loom that should be able to keep pace in the working up of the yarn with the jenny which produced it, solely from motives of philanthropy, he felt bound, now that he had devised the machine, to prove its utility, and bring it into use. To have stopped with the work of invention, would, he conceived, have been to leave the work half undone; and, therefore, at no slight sacrifice of personal inclination, and to the rupture of all old ties, associations, and ways of life, he quitted the ease and seclusion of his parsonage, abandoned the pursuits which had formerly been his delight, and devoted himself to the promotion of his invention. He set up weaving and spinning factories at Doncaster, and, bent on the welfare of his race, began the weary, painful struggle that was to be his ruin, and to end only with his life. "I have the worst mechanical conception any man can have," wrote his friend Crabbe, "but you have my best wishes.

May you weave webs of gold." Alas! the good man wove for himself rather a web of dismal sackcloth, sore and grievous to his peace, like the harsh shirts of hair old devotees used to vex their flesh with for their sins. The golden webs were for other folk's wear,—for those who toiled not with their brain as he had done, but who reaped what they had not sown.

He had invented a machine that was to promote industry, and save the English weavers from being driven from the field, as was beginning to be the case, by foreign weavers; and masters and men were up in arms against him as soon as his design was known. His goods were maliciously damaged,—his workmen were spirited away from him,—his patent right was infringed. Calumny and hatred dogged his steps. After a succession of disasters, his prospects assumed a brighter aspect, when a large Manchester firm contracted for the use of four hundred looms. A few days after they were at work, the mill that had been built to receive them stood a heap of blackened ruins.

Still, he would not give up till all his resources were exhausted,—and surely and not slowly that event drew nigh. The fortune of £30,000 with which he started in the enterprise melted rapidly away; and at length the day came when, with an empty purse, a frame shattered with anxiety and toil, but with a brave, stout heart still beating in his

breast, Cartwright turned his back upon his mills, and went off to London to gain a living by his pen. As he turned from the scene of his misfortunes, he exclaimed,—

> "With firm, unshaken mind, that wreck I see,
> Nor think the doom of man should be reversed for me."

The lion that has once eaten a man has ever after, it is said, a wild craving after human blood. And it would seem that the faculty of invention, once aroused, its appetite for exercise is constant and insatiable. Cartwright having discovered his dormant powers, could no more cease to use them than to eat. A return to his quiet literary ways, fond as he still was of such pursuits, was impossible. An inventor he was, and an inventor he must continue till his eye was glazed, and his brain numbed in death. When a clergyman he set himself to study medicine, and acquired great skill and knowledge in the science, solely for the benefit of the poor parishioners, and now he gave himself up to the labours of invention with the same benevolent motives. Gain had not tempted him to enter the arena,—discouragement and ruin were not to drive him from it. The resources of his ingenuity seemed inexhaustible, and there was no limit to its range of objects. Wool-combing machines, bread and biscuit baking machines, rope-making machines, ploughs, and wheel carriages, fire-preventatives, were in turn invented or improved by him. He predicted the use of steam-ships, and steam-

carriages,—and himself devised a model of the former (with clock-work instead of a steam-engine), which a little boy used to play with on the ponds at Woburn, that was to grow up into an eminent statesman—Lord John Russell. To the very last hour of his life his brain was teeming with new designs. He went down to Dover in his eightieth year for warm sea-bathing, and suggested to his bathman a way of pumping up the water that saved him the wages of two men; and almost the day before his death, he wrote an elaborate statement of a new mode he had discovered of working the steam-engine. Moved by an irresistible impulse to promote the "public weal," he truly fulfilled the resolution he expressed in verse,—

> "With mind unwearied, still will I engage,
> In spite of failing vigour and of age,
> Nor quit the combat till I quit the stage."

In 1808 he was rewarded by Parliament for his invention of the power-loom, and the losses it brought upon him, by a grant of £10,000. He died in October 1823.

V.—SIR ROBERT PEEL.

Cartwright's power-loom was afterwards taken in hand and greatly improved by other ingenious persons —mechanics and weavers. "The names of many clever mechanics," says a writer in the *Quarterly Review*, "who contributed to advance it, step by step, through failure and disappointment, have long

been forgotten. Some broke their hearts over their projects when apparently on the eve of success. No one was more indefatigable in his endeavours to overcome the difficulties of the contrivance than William Radcliffe, a manufacturer at Mellor, near Manchester, whose invention of the dressing-machine was an important step in advance. With the assistance of an ingenious young weaver in his employment, named Johnson, he also brought out the dandy-loom, which effects almost all that can be done for the hand-loom as to motion. Radcliffe was not, however, successful as a manufacturer; he exhausted his means in experiments, of which his contemporaries and successors were to derive the benefit; and after expending immense labour, and a considerable fortune in his improvements, he died in poverty in Manchester only a few years ago."

To the Peel family the cotton manufacture is greatly indebted for its progress. Robert Peel, the founder of the family, developed the plan of printing calico, and his successors perfected it in a variety of ways. While occupied as a small farmer near Blackburn, he gave a great deal of attention to the subject, and made a great many experiments. One day, when sketching a pattern on the back of a pewter dinner-plate, the idea occurred to him, that if colour were rubbed upon the design an impression might be printed off it upon calico. He tested the plan at once. Filling in the pattern with colour on the back

of the plate, and placing a piece of calico over it, he passed it through a mangle, and was delighted with seeing the calico come out duly printed. This was his first essay in calico-printing; and he soon worked out the idea, patented it, and starting as a calico-printer, succeeded so well, that he gave up the farm and devoted himself entirely to that business. His sons succeeded him; and the Peel family, divided into numerous firms, became one of the chief pillars of the cotton manufacture.

To such perfection has calico-printing now been brought, that a mile of calico can be printed in an hour, or three cotton dresses in a minute; and so extensive is the production of that article, that one firm alone—that of Hoyle—turns out in a year more than 10,000 miles of it, or more than sufficient to measure the diameter of our planet.

It was a favourite saying of old Sir Robert Peel, in regard to the importance of commercial wealth in a national point of view, "that the gains of individuals were small compared with the national gains arising from trade;" and there can be no doubt that the success of the cotton trade has contributed essentially to the present affluence and prosperity of the United Kingdom. It has placed cheap and comfortable clothing within the reach of all, and provided well-paid employment for multitudes of people; and the growth of population to which it has led, and consequent increase in the consumption of the various

necessaries and luxuries of life, have given a stimulus to all the other branches of industry and commerce. From one of the most miserable provinces in the land, Lancashire has grown to be one of the most prosperous. Within a hundred and fifty years the population has increased tenfold, and land has risen to fifty times its value for agricultural, and seventy times for manufacturing purposes. From an insignificant country town and a little fishing village have sprung Manchester and Liverpool; and many other towns throughout the country owe their existence to the same source. These are the great monuments to the achievements of Arkwright, Crompton, Peel, and the other captains of industry who wrought this mighty change, and the best trophies of their genius and enterprise.

The Railway and the Locomotive.

I.—"THE FLYING COACH."
II.—THE STEPHENSONS: FATHER AND SON.
III.—THE GROWTH OF RAILWAYS.

The Railway and the Locomotive.

I.—"THE FLYING COACH."

It is the grey dawn of a fine spring morning in the year 1669, and early though it be, there are many folks astir and gathering in clusters before the ancient, weather-stained front of All Souls' College, Oxford. The "Flying Coach" which has been so much talked about, and which has been solemnly considered and sanctioned by the heads of the University, is to make its first journey to the metropolis to-day, and to accomplish it between sunrise and sunset. Hitherto the journey has occupied two days, the travellers sleeping a night on the road; and the new undertaking is regarded as very bold and hazardous. A buzz rises from the knots of people as they discuss its prospects,—some very sanguine, some very doubtful, not a few very angry at the presumption of the enterprise. But six o'clock is on the strike—all the passengers are seated, some of them rather wishful to be safe on the pavement again—the driver has got the reins in his hand—the guard sounds his bugle, and off goes the "Flying Coach" at a rattling pace, amidst the cheering of the crowd and the benedictions of the university "Dons," who have come down to honour the event with their pre-

sence. Learned, liberal-minded men these "Dons" are for the times they live in; but only fancy what they would think if some old seer, whose meditation and research had

> "Pierced the future, far as human eye could see,
> Seen the vision of the world, and all the wonders that would be,"

were to come forth and tell them, that before two centuries were over men would think far less of travelling from Oxford to London in one hour than they then did of doing so in a day, by means of a machine of iron, mounted upon wheels, which should rush along the ground, and drag a load, which a hundred horses could not move, as though it were a feather. Roger Bacon had prophesied as much four centuries before; the Marquis of Worcester was propounding the same theory at that very day, and yet who can blame them if they treated the notion as the falsehood of an impostor, or the hallucination of a lunatic?

In these days when railways traverse the country in every direction, and are still multiplying rapidly, when no two towns of the least size and consideration are unprovided with this mode of mutual communication —when we step into a railway carriage as readily as into an omnibus, and breakfasting comfortably in London, are whisked off to Edinburgh, almost in time for the fashionable dinner hour,—it requires no little effort to realize the incredulity and contempt with which the idea of superseding the stage-coach by the

steam locomotive, and having lines of iron railways instead of the common highways, was regarded for many years after the beginning of the present century. Even after the practicability of the project had been proved, and steam-engines had been seen puffing along the rails, with a train of carriages attached, even so late as 1825, we find one of the leading periodicals—the *Quarterly Review*—denouncing the gross exaggeration of the powers of the locomotive which its promoters were guilty of, and predicting that though it might delude for a time, it must end in the mortification of all concerned. The fact was, said the writer, that people would as soon suffer themselves to be fired off like a Congreve rocket, as trust themselves to the mercy of such a machine, going at such a rate—the rate of eighteen miles an hour, which people now-a-days, accustomed to dash along in express trains at two or three times that speed, would deem a perfect snail-pace.

The "railway" had the start of the locomotive by a couple of centuries, and derives its parentage from the clumsy wooden way-leaves or tram-roads which were laid down to lessen the labour of dragging the coal-waggons to and from the place of shipment in the Newcastle colleries. These were in use from the beginning of the seventeenth century, but it was not till the beginning of the nineteenth that the locomotive steam-engine made its appearance. Watt himself took out a patent for a locomotive in 1784,

but nothing came of it; and the honour of having first proved the practicability of applying steam to the purposes of locomotion is due to a Cornishman named Trevithick, who devised a high-pressure engine of very ingenious construction, and actually set it to work on one of the roads in South Wales. At first, therefore, there was no alliance between the engine and the rail; and though afterwards Trevithick adapted it to run on a tram-way, something went wrong with it, and the idea was for the time abandoned. There was a long-headed engine-man in one of the Newcastle collieries about this time, in whose mind the true solution of the problem was rapidly developing, but Trevithick had nearly forestalled him. The stories of these two men afford a most instructive lesson. A man of undoubted talent and ingenuity, with influential friends both in Cornwall and London, Trevithick had a fair start in life, and every opportunity of distinguishing himself. But he lacked steadiness and perseverance, and nothing prospered with him. He had no sooner applied himself to one scheme than he threw it up, and became engrossed in another, to be abandoned in turn for some new favourite. He was always beginning some novelty, and never ending what he had begun, and the consequence was an almost constant succession of failures. He was always unhappy and unsuccessful. If now and then a gleam of success did brighten on his path, it was but temporary, and was speedily ab-

sorbed in the gloom of failure. He found a man of capital to take up his high-pressure engine, got his locomotive built and set to work, brought his ballast engine into use, and stood in no want of praise and encouragement; and yet, one after another his schemes went wrong. Not one of them did well, because he never stuck to any of them long enough. "The world always went wrong with him," he said himself. "He always went wrong with the world," said more truly those who knew him. His haste, impatience, and want of perseverance ruined him. After actually witnessing his steam engine at work in Wales, dragging a train of heavy waggons at the rate of five miles an hour, he lost conceit of his invention, went away to the West Indies, and did not return to England till Stephenson had solved the difficulty of steam locomotion, and was laying out the Stockton and Darlington Railway. The humble engine-man, without education, without friends, without money, with countless obstacles in his way, and not a single advantage, save his native genius and resolution, had won the day, and distanced his more favoured and accomplished rival. It was reserved for GEORGE STEPHENSON to bring about the alliance of the locomotive and the railroad—"man and wife," as he used to call them—whose union, like that of heaven and earth in the old mythology, was to bear an offspring of Titanic might—the modern railway.

II.—THE STEPHENSONS: FATHER AND SON.

Towards the close of the last century, a bare-legged herd-laddie, about eight years old, might have been seen, in a field at Dewley Burn, a little village not far from Newcastle, amusing himself by making clay-engines, with bits of hemlock-stalk for imaginary pipes. The child is father of the man; and in after years that little fellow became the inventor of the passenger locomotive, and as the founder of the gigantic railway system which now spreads its fibres over the length and breadth, not only of our own country, but of the civilized world, the true hero of the half-century.

The second son of a fireman to one of the colliery engines, who had six children and a wife to support on an income of twelve shillings a-week, George Stephenson had to begin work while quite a child. At first he was set to look after a neighbour's cows, and keep them from straying; and afterwards he was promoted to the work of leading horses at the plough, hoeing turnips, and such like, at a salary of fourpence a-day. The lad had always been fond of poking about in his father's engine house; and his great ambition at this time was to become a fireman like his father. And at length, after being employed in various ways about the colliery, he was, at the age of fourteen, appointed his father's assistant at a shilling a-day. The next year he got a situation as

fireman on his own account; and "now," said he, when his wages were advanced to twelve shillings a-week—"now I'm a made man for life."

The next step he took was to get the place of "plugman" to the same engine that his father attended as fireman, the former post being rather the higher of the two. The business of the plugman, the uninitiated may be informed, is to watch the engine, and see that it works properly—the name being derived from the duty of plugging the tube at the bottom of the shaft, so that the action of the pump should not be interfered with by the exposure of the suction-holes. George now devoted himself enthusiastically to the study of the engine under his care. It became a sort of pet with him; and he was never weary of taking it to pieces, cleaning it, putting it together again, and inspecting its various parts with admiration and delight, so that he soon made himself thoroughly master of its method of working and construction.

Eighteen years old by this time, George Stephenson was wholly uneducated. His father's small earnings, and the large family he had to feed at a time when provisions were scarce and at war prices, prevented his having any schooling in his early years; and he now set himself to repair his deficiencies in that respect. His duties occupied him twelve hours a-day, so that he had but little leisure to himself; but he was bent on improving himself,

and after the duties of the day were over, went to a night-school kept by a poor teacher in the village of Water-row, where he was now situated, on three nights during the week, to take lessons in reading and spelling, and afterwards in the science of pot-hooks and hangers as well; so that by the time he was nineteen he was able to read clearly, and to write his own name. Then he took to arithmetic, for which he showed a strong predilection. He had always a sum or two by him to work out while at the engine side, and soon made great progress.

The next year he was appointed brakesman at Black Collerton Colliery, with six shillings added to his wages, which were now nearly a pound a-week, and he was always making a few shillings extra by mending his fellow-workmen's shoes, a job at which he was rather expert. Busy as he was with his various tasks, he found time to fall in love. Pretty Fanny Henderson, a servant at a neighbouring farm, caught his fancy; and getting her shoes to mend, it cost him a great effort to return them to the comely owner after they were patched up. He carried them about with him in his pocket for some time, and would pull them out, and then gaze fondly at them with as much emotion as the old story tells us the sight of the dainty glass slipper, which Cinderella dropped at the ball, excited in the breast of the young prince. Bent upon taking up house for himself, with Fanny as presiding genius, Stephenson now began to save

up, and declared himself a "rich man" when he put his first guinea in the box.

Instead of spending the Saturday afternoon with his fellow-workmen in the public-house, Stephenson employed himself in taking the engine to pieces, and cleaning it; but besides his attention to work, he was also remarkable for his skill at putting and wrestling, in which he beat most of his comrades. And he was not without pluck either, as he let a great hulking fellow, who was the bully of the village, know to his cost, by giving him such a drubbing as made him a "sadder and wiser man" for some time afterwards. He still continued his attendance at the night-school, till he had got out of the master as much instruction in arithmetic as he was able to supply.

By the time he was of age he had saved up enough to take a little cottage and furnish it comfortably, though, of course, very humbly; and in the winter of 1802, Fanny, now Mrs. George Stephenson, rode home from church on horseback, seated on a pillion behind her husband, with her arms round his waist; and very proud and happy, we may be sure, he was that day, as the neighbours came to their doors to wish him "God speed" in his new mode of life.

Having learned all he could from the village teacher, George Stephenson now began to study mensuration and mathematics at home by himself; but he also found time to make a number of experi-

ments in the hope of finding out the secret of perpetual motion, and to make shoe-lasts and shoes, as well as mend them. At the end of 1803 his only son, Robert, was born; and soon after the family removed to Killingworth, seven miles from Newcastle, where George got the place of brakesman. They had not been settled long here when Fanny died—a loss which affected George deeply, and attached him all the more intensely to the offspring of their union. At this time everything seemed to go wrong with him. As if his wife's death was not grief enough, his father met with an accident which deprived him of his eye-sight, and shattered his frame; George himself was drawn for the militia, and had to pay a heavy sum of money for a substitute; and with his father, and mother, and his own boy to support, at a time when taxes were excessive and food dear, he had only a salary of £50 or £60 a-year to meet all claims. He was on the verge of despair, and would have emigrated to America, if, fortunately for our country, he had not been unable to raise sufficient money for his passage. So he had to stay in the old country, where a bright and glorious future awaited him, dark and desperate as the prospect then appeared.

He still went on making models and experiments, and perfecting his knowledge of his own engine. To add to his earnings he also took to clock-cleaning, with the view of saving up enough

to give his boy the best education it was in his power to bestow. "In the earlier period of my career," he used afterwards to say, "when Robert was a little boy, I saw how deficient I was in education, and I made up my mind that he should not labour under the same defect, but that I would put him to a good school, and give him a liberal training. I was, however, a poor man, and how do you think I managed? I betook myself to mending my neighbours' clocks and watches at nights, after my daily labour was done, and thus I procured the means of educating my son." George began by teaching his son to work with him; and when the little chap could not reach so high as to put a clock-hand on, would set him on a chair for the purpose, and very proud Robert was whenever he could "help father" in any of his jobs.

About this time a new pit having been sunk in the district where he worked, the engine fixed for the purpose of pumping the water out of the shaft was found a failure. This soon reached George's ears. He walked over to the pit, carefully examined the various parts of the machinery, and turned the matter over in his mind. One day when he was looking at it, and almost convinced that he had discovered the cause of the failure, one of the workmen came up, and asked him if he could tell what was wrong.

"Yes," said George; "and I think I could alter it, and in a week's time send you to the bottom."

George offered his services to the engineer. Every expedient had been tried to repair the engine, and all had failed. There could be no harm, if no good, in Stephenson trying his hand at it. So he got leave, and set to work. He took the engine entirely to pieces, and in four days had repaired it thoroughly, so that the workmen could get to the bottom and proceed with their labours. George Stephenson's skill as an engine-doctor began to be noised abroad, and secured him the post of engine-wright at Killingworth, with a salary of £100 a-year. Robert was now old enough to go to school, and was sent to one in Newcastle, to which, dressed in a suit of coarse grey stuff cut out by his father, he rode every day upon a donkey. Robert spent much of his spare time in the Literary and Philosophical Institute of Newcastle; and would sometimes take home a volume from the library, which father and son would eagerly peruse together. Occasionally they tried chemical experiments together; and now and then Robert would try his hand by himself. On one occasion he electrified the cows in an adjacent enclosure by means of an electric kite, making the bewildered animals dash madly about the field, with their tails erect on end; and another time he administered a severe electric shock to his father's Galloway pony, which nearly knocked it over, and drew down upon him the affected wrath of his father, who, coming out at the instant, shook his whip at

him and called him a mischievous scoundrel, though pleased all the while at the lad's ingenuity and enterprise. As an early proof of the former, there still stands over the cottage door at Killingworth a sun-dial, constructed by Robert when he was thirteen years old, with some little help from his father.

The idea of constructing a steam-engine to run on the colliery tram-roads leading to the shipping-place was now receiving considerable attention from the engineering community. Several schemes had been propounded, and engines actually made; but none of them had been brought into use. A mistaken notion prevailed that the plain round wheels of an engine would slip round without catching hold of the rails, and that thus no progress would be made; but George Stephenson soon became convinced that the weight of the engine would of itself be sufficient to press the wheels to the rails, so that they could not fail to bite. He turned the subject over and over in his mind, tested his conceptions by countless experiments, and at length completed his scheme. Money for the construction of a locomotive engine on his plan having been supplied by Lord Ravensworth, one was made after many difficulties, and placed upon the tram-road at Killingworth, where it drew a load of 30 tons up a somewhat steep gradient at the rate of four miles an hour. Still there was very little saving in cost, and little advance in speed as compared with horse-power; but

in a second one, which Stephenson quickly set about constructing, he turned the waste steam into the chimney to increase the draught, and thus puff the fuel into a brisker flame, and create a larger volume of steam to propel the locomotive. The fundamental principles of the engine thus formed remain in operation to this day; and it may in truth be termed the progenitor of the great locomotive family.

In 1821 George Stephenson got the appointment of engineer, with £300 of salary, to the Stockton and Darlington Railway Company, in the Act of Parliament for which power was given to use locomotive engines, if needful, either for the conveyance of goods or passengers. When the line was opened, it was worked partly by horses and partly by locomotive and stationary engines. This led to a partnership between Mr. Edward Pease of Darlington, the chief projector of the line, and Stephenson, in a locomotive manufactory in Newcastle,—for many years the only one of the kind in existence.

Meanwhile, young Robert Stephenson, having spent a year or two in gaining a practical acquaintance with the machinery and working of a colliery, went to the University of Edinburgh, where he spent a session in attending the courses of lectures on chemistry, natural philosophy, and geology. He made the best of his opportunities; and that he might profit to the utmost by the lectures, he studied short-hand, and took them all down *verbatim*, transcribing his notes

every evening before he went to bed. Robert brought home the prize for mathematics, and showed he had made so much progress at college that, though the £80 which the session cost was a large sum to his father at that time, George never failed, then or afterwards, to declare that it was one of the best investments he had ever made.

After a year or two in his father's locomotive factory, Robert spent two or three years in charge of the machinery of a mining company in Columbia, and returned to England at the close of 1827, to find the great question, "Whether locomotives can be successfully and profitably applied to passenger traffic?" hotly agitated, his father, almost alone, taking the side of the travelling, against that of the fixed engines, and insisting that the wheel and the rail were clearly and closely part of one system.

The success of the Darlington line induced the Liverpool merchants to project a line between that town and Manchester; and George Stephenson was almost unanimously chosen engineer, though it was still undetermined whether the new line should be worked by steam or horse power. But, apart from that question, a great, and, as it appeared to most of the engineers of the time, an insurmountable difficulty existed in the quagmire of Chat Moss,—an enormous mass of watery pulp, which rose in height in wet, and sank in dry weather like a sponge, and

over whose treacherous depths it was pronounced impossible to form a firm road. It was perfect madness to think of such a thing, said the engineers, and none of them would support Stephenson's scheme; but he resolved to see what could be done. Truck-load after truck-load of stuff was emptied into the moss, and still the insatiable bog kept gaping as though it had not had half a feed. The directors, alarmed, would have abandoned the project, had they not been so deeply involved that they were obliged to let Stephenson continue. But he never doubted himself—not for a moment. He only pushed on the works more vigorously; and, before six months were over, the directors found themselves whirling along over the very bog they expected all their capital was to be fruitlessly sunk to the bottom of. Still, no decision had been come to as to whether locomotive or fixed engines were to be adopted; and the Stephensons were still battling bravely in favour of the locomotive against a host of opponents. Robert did his father good service by the able and pithy pamphlets which he wrote on the subject; and at length their perseverance was rewarded by the directors consenting to employ a locomotive, if they could get one that would run at the rate of ten miles an hour, and not weigh more than six tons, including tender; and offering a reward of £500 for the best engine fulfilling these conditions. George Stephenson and his son set to work immediately, and the product of their

united skill and ingenuity was the celebrated *Rocket*, which carried off the prize, and attained a speed of twenty-nine miles on the opening day. The practicability and success of the locomotive was now beyond a doubt; from that day forward public opinion began to turn. Of course, for many a long year afterwards there were not wanting numbers of bigoted men of the old school who cried down the new-fangled system, and would hear of no means of transit but the stage-coach and the canal-boat. But shrewd folk, like the old Duke of Bridgewater, whose faculties were sharpened by their pockets being in danger, could not help crying out, "There's mischief in these tram-ways! I wish the canals mayn't suffer;" and, within ten years of the day when the *Rocket* went puffing triumphantly along the Liverpool and Manchester line, most sensible people had become convinced of the importance of the locomotive railway, and scarcely a principal town in the country but was supplied with a line.

The Stephensons had fought a hard fight for their protegé, "rail and wheel," and now they were to reap the fruits of their enterprise and foresight. To nearly all the most important of the new lines George Stephenson acted as engineer; and thus, in the course of two years, above 321 miles of railway were constructed under his superintendence, at a cost of £11,000,000 sterling. Robert at first left his father to attend to the laying out of railways, and directed his attention

to the improvement of the locomotive in all its details, experimenting incessantly, and trying now one new device, now another. "It was astonishing," says Mr. Smiles, "to observe the rapidity of the improvements effected,—every engine turned out of Stephenson's workshops exhibiting an advance upon its predecessor in point of speed, power, and working efficiency.

By this time George had taken up his residence at Tapton House, near Chesterfield, where he continued to reside for the remainder of his life. Close by were some extensive coal-pits, which he had taken in lease, and from which he supplied London with the first coals sent by railway. He was now a man of wealth and fame, known and honoured throughout his own country, and in many foreign ones, and blessed with many a staunch, true friend. More than once he was offered knighthood by Sir Robert Peel, but declined the honour. As he grew up in years, he gradually abandoned his railway business to the charge of his son, and settled down into a quiet country gentleman of agricultural tastes. He was very fond of gardening and farming, and spent many a long day superintending the operations in the fields. When a boy, he had always been very fond of taming birds and rabbits, and had once had flocks of robins, which, in the hard winter, used to come hopping round his feet for crumbs. And now, in his old age, he had special pets among his dogs and horses, and was proud of

his superior breed of rabbits. There was scarcely a nest on his estate that he was not acquainted with; and he used to go round from day to day to look at them, and see that they were kept uninjured.

The year before his death he visited Sir Robert Peel at Drayton Manor. Dr. Buckland, the geologist, was of the party. One Sunday, as they were returning from church, they observed a train speeding along the valley in the distance.

"Now, Buckland," said Mr. Stephenson, "I have a poser for you. Can you tell me what is the power that is driving that train?"

"Well," said the other, "I suppose it is one of your big engines."

"But what drives the engine?"

"Oh, very likely a canny Newcastle driver."

"What do you say to the light of the sun?"

"How can that be?" asked the professor.

"It is nothing else," said the engineer. "It is light bottled up in the earth for tens of thousands of years—light, absorbed by plants and vegetables, being necessary for the condensation of carbon during the process of their growth, if it be not carbon in another form; and now, after being buried in the earth for long ages in fields of coal, that latent light is again brought forth and liberated, made to work as in that locomotive, for great human purposes."

On the 12th of August 1848, this great, good man—one of the truest heroes that ever lived, and

one of the greatest benefactors of our country—passed from among us, leaving his son, Robert, to develop and extend the great work of which he had laid the foundation.

Among one of the first railways of any extent of which Robert Stephenson had the laying out, was the London and Birmingham; and it is related, as an illustration of his conscientious perseverance in executing the task, that in the course of the examination of the country he walked over the whole of the intervening districts upwards of twenty times. Many other lines, in England and abroad, were executed by him in rapid succession; and it was stated a few years ago, that the lines of railway constructed under his superintendence had involved an outlay of £70,000,000 sterling.

The three great works, however, with which his name will always be most intimately associated, and which are the grandest monuments of his genius, are the High Level Bridge at Newcastle, the Britannia Bridge across the Menai Straits, and the Victoria Bridge across the St. Lawrence at Montreal. The first two are sufficiently well known—the one springing across the valley of the Tyne, between the busy towns of Newcastle and Gateshead; the other spanning, in mid air, a wide arm of the sea, at such a height that vessels of large burden in full sail can pass beneath. The third great effort of Robert Stephenson's prolific brain he did not live to see the

completion of. The Victoria Bridge at Montreal is constructed on the same principle as the Britannia Bridge, but on a much larger scale. "The Victoria Bridge," says Mr. Smiles, "with its approaches, is only sixty yards short of two miles in length. In its gigantic strength and majestic proportions, there is no structure to compare with it in ancient or modern times. It consists of not less than twenty-five immense tubular bridges joined into one; the great central span being 332 feet, the others, 242 feet in length. The weight of the wrought iron on the bridge is about 10,000 tons, and the piers are of massive stone, containing some 8000 tons each of solid masonry.

After the completion of the Britannia Bridge, and again after the opening of the High Level Bridge, Robert Stephenson was offered the honour of knighthood, which, like his father before him, he respectfully declined. In 1857 he received the title of D.C.L. from the University of Oxford; and for many years before his death he represented Whitby in Parliament. He was passionately fond of yachting, and almost immediately after a trip to Norway in the summer of 1859, he was seized with a mortal illness, and died in the beginning of October. On the 14th October he was buried in Westminster, amongst the illustrious dead of England.

No man could be more beloved than Robert Stephenson was by a wide circle of friends, and

none better deserved it. "In society," writes one who had opportunities of intercourse with him, "he was simply charming and fascinating in the highest degree, from his natural goodness of heart and the genial zest with which he relished life himself and participated its enjoyment with others. He was generous and even princely in his expenditure—not upon himself, but on his friends. On board the *Titania*, or at his house in Gloucester Square, his frequent and numerous guests found his splendid resources at all times converted to their gratification with a grace of hospitality which, although sedulous, was never oppressive. There was nothing of the patron in his manner, or of the Olympic condescension which is sometimes affected by much lesser men. A friend (and how many friends he had!) was at once his equal, and treated with republican freedom, yet with the most high-bred courtesy and happy considerateness. . . . . His payment of half the debt of £6000, which weighed like an incubus on an institution at Newcastle, is generally known; but his private charities were as boundless as his nature was generous, and as quietly performed as that nature was unostentatious. Such, then, was Robert Stephenson, as complete a character in the multifarious relations of life as probably any man has met or will meet in the course of his experience. Not unlike, or rather exceedingly *like*, his father in some respects, especially in the easy, unimposing manner in which

he went about his life's work, he was hardly to be accounted his father's inferior, except perhaps in the heroic quality of combativeness. Father and son, independently of each other, and both in conjunction, have left grand and beneficent results to posterity, and both recall to us Monckton Milnes's men of old, who

> "'Went about their gravest tasks
> Like noble boys at play.'"

III.—THE GROWTH OF RAILWAYS.

It was about the year 1818 that Thomas Gray of Nottingham, travelling in the north of England, happened to visit one of the collieries. As he stood watching a train of loaded waggons being propelled by steam along the tram-road which led from the mouth of the pit to the wharf where the coals were shipped, the idea flashed through his mind that the same system was applicable to the ordinary purposes of locomotion.

"Why!" he exclaimed to the engineer who was showing him over the place,—"why are there not tram-roads laid down all over England so as to supersede our common roads, and steam engines employed to drag waggons full of goods, and carriages full of passengers along them, instead of horse-power?"

"Propose that to the nation," replied his companion, "and see what you will get by it. Why, sir, you would be worried to death for your pains."

Gray was not to be balked, however. The idea took firm possession of his mind, and became the one great subject of his thoughts and conversation. He talked about it to everybody whom he met, and who had patience to listen to him, wrote letters and memorials to public men, and afterwards appealed to the people at large. He was laughed at as a whimsical, crochetty fellow, and no one gave any serious attention to his views. Mr. Jones of Gromford Manor, and Mr. Pease of Darlington, also distinguished themselves by their agitation in favour of railways, at a time when they were regarded with suspicion and alarm. The growing trade of Liverpool and Manchester, and other large towns, however, spoke more imperatively and forcibly in favour of the new project than any amount of individual agitation. The means of communication between the various manufacturing towns had fallen far behind their wants; and it was at length felt that some new system must be adopted. The railroad and the locomotive got a trial; and before long the carriers' carts and the stage coaches were driven off the road for want of custom, although the conveyance of goods and passengers throughout the country went on multiplying an hundred-fold. One can fancy the astonishment and awe with which the country-folk watched the progress of the first railway train through their peaceful acres,—how old and young left their work and rushed out to see the marvellous spectacle,

—how the "oldest inhabitants" shook their heads, and muttered about changed times,—how the horses in the field trembled with fear, and threw up their heels at their iron rival as it went snorting past—a strange, iron monster, the handicraft of man, able to drag the heaviest burdens, and yet outstrip *Flying Childers* or *Eclipse*, as fresh at the end of a journey as at the beginning, and never to be tired out by any toil, if only kept in meat and drink. Just as in the days of Charles the First, honest, short-sighted folk prophesied the ruin of the empire and a judgment upon the use of coaches, and bewailed the misfortunes of the hundreds of able-bodied men who would be thrown out of employment; so in the early days of the railroad, great fears were entertained that the horses' occupation would be gone, and that the noble breed would quickly become extinct. There was no measure to the lamentations over the ruin of that great institution of English life—the stage-coach, with its gallant driver and guard, and spanking team.

The extension of the railway system is one of the wonders of our time. The few score miles of railroad planted in 1825 have put forth offshoots and branches, till now a mighty net-work of some ten thousand miles in all, is spread over the three kingdoms, with many fresh shoots in bud. Up to the end of 1834, when not a hundred miles of railway were open, the annual average of travellers by coach was

some six millions a year; ten years afterwards there were more than four times that number, and to-day the annual average is more than a hundred millions! The number of persons employed upon the working railroads of the United Kingdom amount to about one hundred and thirty thousand, while nearly half as many find employment in the construction of new lines.

A few facts, stated by the late Mr. Robert Stephenson, illustrate in a very striking manner the gigantic porportion of the railway system of Great Britain:—The railway has pierced the earth with tunnels to the extent of more than fifty miles, and there are about twelve miles of viaducts in the vicinity of London alone. The earthworks which have been thrown up would measure 550,000,000 cubic yards, beside which St. Paul's would shrink to a pigmy, for it would form a pyramid a mile and a half high, with a base larger than the whole of St. James's Park. Every moment four tons of coals flashes into steam twenty tons of water—as much water as would suffice to supply the domestic and other wants of a town the size of Liverpool, and as much coal as equals half the consumption of the metropolis. The wear and tear is so great that twenty thousand tons of iron have to be replaced annually, and three hundred thousand trees, or as much as five thousand acres could produce, have to be felled for sleepers.

When George Stephenson was planning the Liverpool and Manchester line, the directors en-

treated him, when they went to Parliament, not to talk of going at a faster rate than ten miles an hour, or he "would put a cross on the concern." George was sanguine, however, and spoke of fifteen miles an hour, to the astonishment of the committee, who began to think him crazy. The average speed is now twenty-five miles an hour, and a mile a minute can be done, if need be. The wind is hard pushed to keep ahead of a good engine at its fullest speed.* The express trains on the "broad gauge" of the Great Western travel at the rate of fifty-one miles an hour, or forty-three, including stoppages. To attain this rate, a speed of sixty miles an hour is adopted midway between some of the stations, and even seventy miles an hour have been reached in certain experimental trips. The engines on this line can draw a passenger-train weighing one hundred and twenty tons at a speed of sixty miles an hour, the engine and tender themselves weighing an additional fifty-two tons. The ordinary luggage-trains weigh some six hundred tons each. The locomotive, however, goes on the principle that the labourer is worthy of his hire; if it works hard, it eats voraciously. At ordinary mail speed the engine consumes about twenty lbs. of coke per mile; so that, costing £2500 to begin with, and spending an allowance of £2000 a year—as much as an under-

* The wind is calculated to travel at the rate of eighty-two feet in a second; the pace of a steam-engine, at the rate of sixty miles an hour, would be rather more.

secretary of state—the locomotive is rather an extravagant customer—only, it works very hard for the money, and earns it over and over again. With all its strength and size, the locomotive is a much more delicate concern than would be supposed; the 5416 different pieces of which it is composed must be put together as carefully as a watch, and, though guaranteed to go two years without a doctor, exacts the most devoted attention from its guardians to keep it in order.

It would fill a volume of huge dimensions to dilate on all the phases of the social revolution which the modern railway has wrought in our own and other countries; how it is daily annihilating time and space, and making the Land's End and John o'Groat's House next door neighbours; rubbing down old prejudices and jealousies, both national and provincial, promoting commerce, developing manufacture, transforming poor little villages into flourishing towns, and industrious towns into mighty cities; carrying civilization into the heart of the jungle and the desert, and, with its twin-brother, the steam-ship, joining hands and hearts in peace and amity all the world over. After the wonders of the last thirty years, who can doubt that our children, at the close of the century, will regard us as little less backward than we now do our fathers at its dawn?

The Lighthouse.

I.—THE EDDYSTONE.
II.—THE BELL ROCK.
III.—THE SKERRYVORE.

The Lighthouse.

"Far in the bosom of the deep,
O'er these wild shelves my watch I keep;
A ruddy gleam of changeful light,
Bound on the dusky brow of night;
The seaman bids my lustre hail,
And scorns to strike his timorous sail."—SCOTT.

I.—THE EDDYSTONE.

WHEN worthy Mr. Phillips, the Liverpool Quaker, taking thought in what way he could best benefit his fellow-creatures, built the beacon on the Smalls Rock in 1772, he could hardly have made a happier selection of "a great good to serve and save humanity." There are few enterprises more heroic or beneficent than those connected with the construction and management of lighthouses. From first to last, from the rearing of the column on the rock to the monotonous, nightly vigil in attendance on the lamps—from the setting to the rising of the sun—the valour, intrepidity, and endurance, of all concerned are called into play, and the wild perils and stirring adventures they experience impart to the story of their labours a thrilling and romantic interest. In the case of the Smalls Lighthouse, for instance, Whiteside, the self-taught engineer, and his party of Cornish miners had no sooner landed,

and got a long iron shaft worked a few feet into the rock, than a storm arose that drove away their cutter, and kept them clinging with the tenacity of despair to the half-fastened rod for three days and two nights, when the wind fell and the sea calmed, and they were rescued, rather dead than alive, numbed from their long immersion in the water, which rose almost to their necks, and exhausted from want of food. And after the lighthouse had been erected, the engineer and some of his men again found themselves, as a paper in a bottle they had cast into the sea revealed to those on shore, in a "most dangerous and distressed condition on the Smalls," cut off from the mainland by the stormy weather, without fuel, and almost at the end of their stock of food and water—in which alarming situation they had to remain some time before their friends could get out to their relief. Most sea-girt beacons have their own legends of similar perils and fortitude; and the narratives of the erection of the three great lighthouses of Eddystone, Inchcape, and Skerryvore, which may be selected as the types of the rest, are full of incidents as exciting as any "hair breadth 'scapes i' the imminent deadly breach."

About fourteen miles south from Plymouth, and ten from the Ram's Head, on the Cornish coast, lies a perilous reef of rocks, against which the long rolling swell of the Atlantic waves dashes with appalling

force, and breaks up into those swirling eddies from which the reef is named—the Eddystone. Upon these treacherous crags many a gallant vessel has foundered and gone down within sight of the shore it had scarcely quitted or was just about to reach ; and situated in the midst of a much frequented track, the rapid succession of calamities at the Eddystone was not long in awakening men's minds to the necessity of some warning light. The exposure of the reef to the wild fury of the Atlantic, and the small extent of the surface of the chief rock, however, rendered the construction of a lighthouse in such a situation a work of great and (as it was long considered) insuperable difficulty. The project was long talked of before any one was found daring enough to attempt the task ; and when at length in 1696 Henry Winstanley stepped forward to undertake it, he might have been thought of all others the very last from whose brain so serious a conception would have emanated. The great hobby of his life had been to fill his house at Littlebury, in Essex, with mechanical devices of the most absurd and fantastic kind. If a visitor, retiring to his bedroom, kicked aside an old slipper on the floor, purposely thrown in his way, up started a ghost of hideous form. If, startled at the sight, he fell back into an arm chair placed temptingly at hand, a pair of gigantic arms would instantly spring forth and clasp him a prisoner in their rude embrace. Tired of these disagree-

able surprises, the astonished guest perhaps took refuge in the garden, and sought repose in a pleasant arbour by the side of a canal; but he had scarcely seated himself, when he found himself suddenly set adrift on the water, where he floated about till his whimsical host came to his relief. Such was the man who now entered upon one of the most formidable engineering enterprises in the world.

Although Winstanley's lighthouse was but a slight affair compared with its successors, it occupied six years in the erection—the frequent rising of the sea over the rock, and the difficulty and danger of passing to and from it greatly retarding the operations, and rendering them practicable only during a short summer season. For ten or fourteen days after a storm had passed, and when all was calm elsewhere, the ground-swell from the Atlantic was often so heavy among these rocks that the waves sprang two hundred feet, and more, in the air, burying the works from sight. The first summer was spent in boring twelve holes in the rock, and fixing therein twelve large irons as a holdfast for the works that were to be reared. The next season saw the commencement of a round pillar, which was to form the steeple of the tower, as well as afford protection to the workmen while at their labours. When Winstanley bade farewell to the rock for that year, the tower had risen to the height of twelve feet; and resuming operations next spring, he built at it till it reached

the height of eighty feet. Having got the apartments fit for occupation, and the lantern set up, Winstanley determined to take up his abode there with his men, in order that no time might be lost in going to and from the rock. The first night they spent on the rock a great storm arose, and for eleven days it was impossible to hold any communication with the shore. "Not being acquainted with the height of the sea's rising," writes the architect, "we were almost drowned with wet, and our provisions in as bad a condition, though we worked night and day as much as possible to make shelter for ourselves." The storm abating, they went on shore for a little repose; but soon returning, set to work again with undiminished energy.

On the 14th November of the same year (1698), Winstanley lighted his lantern for the first time. A long spell of boisterous weather followed, and it was not till three days before Christmas that they were able to quit their desolate abode, being "almost at the last extremity for want of provisions; but by good Providence then two boats came with provisions and the family that was to take care of the light; and so ended this year's work."

It was soon found that the sea rose to a much greater height than had been anticipated, the lantern, although sixty feet above the rock, being often "buried under water." Winstanley was, therefore, under the necessity of enlarging the tower and carrying it to a

greater elevation. The fourth season, accordingly, was spent in encasing the tower with fresh outworks, and adding forty feet to its height. This proved too high for its strength to bear; and in the course of three years the winds and waves had made sad havoc in the unstable fabric.

In November 1703, Winstanley went out to the rock himself, accompanied by his workmen, to institute the repairs. As he was putting off in the boat from Plymouth, a friend who had for some time before been watching the condition of the lighthouse with much anxiety, mentioned to him his suspicion that it was in a bad way, and could not last long. Winstanley, full of faith in the stability of his work, replied that "he only wished to be there in the greatest storm that ever blew under the face of the heavens, that he might see what effect it would have on his structure." And with these words he shoved off from the beach, and made for the rock.

With the last gleams of daylight, before the night fell and shrouded it from view, the tower was seen rising proudly from the midst of the waters. Before the dawn it had disappeared for ever, and the waves were lashing fiercely round the bare bleak ledge of the fatal rock. Poor Winstanley had had his presumptuous wish only too fully realized. The storm of the 26th November was one of the most fearful that ever ravaged our shores. The whole coast suffered severely from its fury, and when the morn-

ing came, not a sign remained of the lighthouse, architect, or workmen, save a fragment of chain-cable wedged firmly into a crevice of the rock. The disappearance of the warning light was quickly followed by the wreck of a large homeward-bound man-of-war, and the loss of nearly all her crew, upon the rocks.

This first Eddystone lighthouse was a strange, fantastic looking structure, deficient in every element of stability, and the wonder was not that it fell in pieces as it did, but that it was able to withstand so long the boisterous weather of the Channel. But if of little merit as an architect, Winstanley at least deserves respect, as Smeaton remarks, for the heroism he displayed in undertaking "a piece of work that before had been looked on as impossible."

For four years the Eddystone remained bare and untenanted, till, in the summer of 1706, the erection of a new lighthouse was commenced under the superintendence of John Rudyerd, by profession a silk-mercer in Ludgate Hill, but by natural genius an engineer of considerable merit. With such skill and energy did he apply himself to the work, that before two summers were over his tower was completed, and its friendly light beamed over the troubled waters and sunken crags. Rudyerd's lighthouse was entirely of wood, weighted at the base by a few courses of mason work, and 92 feet in height. In form, it was a smooth, solid cone of elegant simpli-

city, unbroken by any of those ornamental outworks, which offered the wind and sea so many points to lay hold of, in Winstanley's whimsical pagoda. Smeaton speaks of Rudyerd's tower as a masterly performance; and had it not been destroyed by fire, forty-six years after its erection, there seems little reason to suppose it might not have been standing to this day,—although no doubt the ravages of the worm in the wood would have demanded frequent repairs. On the 2d December 1755, some fishermen who happened to be on the beach very early in the morning preparing their nets, were startled by the sight of volumes of smoke issuing from the light-house. They instantly gave the alarm, and a boat was quickly manned for the relief of the sufferers. It did not reach the rock till about ten o'clock, and the fire had then been raging for eight hours. It was first discovered by the light-keeper upon watch who, going into the lantern about two o'clock in the morning to snuff the candles, found the place filled with smoke. He opened the door of the lantern into the balcony, and a mass of flame immediately burst from the inside of the cupola. He lost no time in seizing the buckets of water kept at hand, and dashing them over the fire, but without effect. His two companions were asleep, and it was some time before they heard his shouts for assistance. When at length they did bestir themselves, all the water in the house was exhausted. The light-keeper

—an old man in his ninety-fourth year—urged them to replenish the buckets from the sea; but the difficulty of lowering the buckets to such a depth, and their confusion and terror at the sudden catastrophe and their impending fate, destroyed their presence of mind, and rendered them quite powerless. The old man did his best to prevent the advance of the flames; but, exhausted by the unavailing labour, and severely injured by the melting lead from the roof, he had to desist. As the fire spread from point to point, with rapid strides descending from the summit to the base, the poor wretches fled before it, retreating from room to room, till at last they were driven to seek shelter from the blazing timbers and red hot bars, in a cleft of the rock. There they were found by their preservers, crouching together half dead with suffering and fright. It was with the greatest difficulty that they were got into the boat; and they had no sooner reached the shore than one of them, crazed by the terrors he had undergone, ran away, and was never heard of more. The old man lingered on for a few days in great agony, and died from the injuries he had received.

Such was the fate of the second lighthouse on the Eddystone,—one element revenging, as it were, the conquest over another.

In spite of the fatality which seemed to attend these lighthouses, the lessees of the Eddystone—for it was then in private hands, and did not come into

the hands of the Trinity House till many years after —resolved to make another attempt; and this time they selected as the architect one of the ablest professional men of the day, and with sagacious liberality, adopted his advice to build it of stone and granite.

Smeaton truly belonged to the class of heaven-born engineers. From his earliest years the bent of his genius unmistakably revealed itself. Before he was six years old, he one day terrified his parents by climbing to the top of a barn to fix up some contrivance he had put together, after the fashion of a windmill; and another time he constructed a pump that raised water, after watching some workmen sinking one. And as he grew older, his efforts took a more ambitious range, and were all equally remarkable for their originality and success. His father destined him for the bar; but his inclination for engineering was so irresistible, that he allowed him to resign all chance of the woolsack, and set up in business as a mathematical instrument maker. He gradually advanced to the profession of civil engineering,—which he was the first man in England to pursue, and which he may be said to have created.

It was in 1756 he commenced the construction of the great work which may be regarded as the monument of his fame. Having decided that his lighthouse should be of stone, the next point to be settled

was its form. His thoughts, he tells us in his book, instinctively reverted to the analogy between a lighthouse shaft and the trunk of a stately oak. He remarked the spreading roots taking a broad, firm grip of the soil, the rise of the swelling base, gradually lessening in girth in a graceful curve, till a preparation being required for the support of the spreading boughs, a renewed swelling of diameter takes place; and he held that cutting off the branches we have, in the trunk of an oak, a type of such a lighthouse column as is best adapted to resist the influence of the winds and waves. Whether or not Smeaton arrived at the form of his lighthouse, which has since become the model for all others, from this fanciful analogy, its appearance rising from the rock presents a strong resemblance to a noble tree stripped of its boughs and foliage.

Smeaton commenced the undertaking by visiting the rock in the spring of 1756, accurately measuring its very irregular surface, and in order to ensure exactness in his plans, making a model of it. In the summer of the same year he prepared the foundation by cutting the surface of the rock in regular steps or trenches, into which the blocks of stone were to be dovetailed. The first stone was laid in June 1757, and the last in August 1759. Of that period there were only 431 days when it was possible to stand on the rock, and so small a portion even of these was available for carrying on the work, that it is

calculated the building in reality occupied but six weeks. The whole was completed without the slightest accident to any one; and so well were all the arrangements made, that not a minute was lost by confusion or delay amongst the workmen.

The tower measures 86 feet in height, and 26 feet in diameter at the level of the first entire course. the diameter under the cornice being only 15 feet. The first twelve feet of the structure form a solid mass of masonry,—the blocks of stone being held together by means of stone joggles, dovetailed joints, and oaken tree-nails. All the floors of the edifice are arched; to counteract the possible outburst of which, Smeaton bound the courses of his stone work together by belts of iron chain, which, being set in grooves while in a heated state, by the application of hot lead, on cooling, of course, tightened their clasp on the tower. Throughout the whole work the greatest ingenuity is displayed in obtaining the greatest amount of resistance, and combining the two great principles of strength and weight,—technically speaking, cohesion and inertia.

On the 16th October 1759, the warning light once more, after an interval of four years, shone forth over the troubled waters from the dangerous rock; but it was but a feeble illumination at the best, for it came from only a group of tallow candles. It was better than nothing, certainly; but the exhibition of a few glimmering candles was but a

paltry conclusion to so stupendous an undertaking. For many years, however, no stronger light gleamed from the tower, till, in 1807, when it passed from the hands of private proprietors into the charge of the Trinity House, the mutton dips were supplanted by Argand burners, with silvered copper reflectors.

Imperfect, however, as used to be the lighting apparatus, the Eddystone Beacon has always been a great boon to all those "that go down to the sea in great ships," and has robbed these perilous waters of much of their terror. We can readily sympathize with the exultation of the great engineer who reared it, when standing on the Hoe at Plymouth, he spent many an hour, with his telescope, watching the great swollen waves, in powerless fury, dash against his tower, and "fly up in a white column, enwrapping it like a sheet, rising at the least to double the height of the tower, and totally intercepting it from sight." It is now more than a hundred years since Smeaton's Lighthouse first rose upon the Eddystone; but, in spite of the many furious storms which have put its stability to rude and searching proof, it still lifts its head proudly over the waves, and shows no signs of failing strength.

II.—THE BELL ROCK.

The Inch Cape, or Bell Rock, is a long, narrow reef on the east coast of Scotland, at the mouth of the Frith of Tay, and some dozen of miles from the

nearest land. At high water the whole ledge is buried out of sight; and even at the ebb the highest part of it is only three or four feet out of the water. In the days of old, as the tradition goes, one of the abbots of Arbroath, among many good works, exhibited his piety and humanity by placing upon a float attached to the perilous reef a large bell, so suspended as to be tolled by the rising and falling of the waves.

"On a buoy, in the storm it floated and swung,
And over the waves its warning rung."

Many a storm-tossed mariner heard the friendly knell that warned him of the nearness of the fatal rock, and changed his course before it was too late, with blessings on the good old monk who had hung up the bell; but after some years, one of the pirates who infested the coast cut it down in wanton cruelty, and was one of the first who suffered from the loss. Not long after, he perished upon this very rock, which a dense fog shrouded from sight, and no bell gave timely warning of.

"And even in his dying fear,
One dreadful sound did the rover hear;
A sound as if with the Inch Cape Bell,
The devil below was ringing his knell."

After the lapse of many years, two attempts were made to raise a beacon of spars upon the rock; but one after the other they fell a prey to the angry waves, and were hardly set up before they disappeared. It was not till the beginning of the century

that the Commissioners of Northern Lighthouses took up the idea of erecting a lighthouse on this reef, the most dangerous on all the coast. Several years elapsed before they got the sanction of Parliament to the undertaking, and 1807 arrived before it was actually entered upon.

Mr. Robert Stevenson, to whom the work was intrusted as engineer, had from a very early age been employed in connection with lighthouses. He went almost directly from school to the office of Mr. Thomas Smith of Edinburgh, and when that gentleman was appointed engineer to the Northern Lighthouse Commissioners, became his assistant, and afterwards successor. When only nineteen, Mr. Stevenson superintended the construction of the lighthouse on the island of Little Cumbray; and during the time he was engineer to the Commissioners, which post he held till 1842, he erected no fewer than forty-two lighthouses, and introduced a great many valuable improvements into the system. His reputation, however, will be chiefly perpetuated as the architect of the Bell Rock Lighthouse.

On the 17th August 1807, Mr. Stevenson and his men landed on the rock, to the astonishment and discomposure of the seals who had, from time immemorial, been in undisturbed possession of it, and now floundered off into the water on the approach of the usurpers. The workmen at once set about preparing the rock for the erection of a temporary

pyramid on which a barrack-house was to be placed for the reception of the workmen. They could only work on the rock for a few hours at spring-tide. As soon as the flood-tide began to rise around them, putting out the fire of the smith's forge, and gradually covering the rock, they had to gather up their tools and retreat to a floating barrack moored at a considerable distance, in order to reach which they had to row in small boats to the tender, by which they were then conveyed to their quarters. The operations of this first season were particularly trying to the men, on account of their having to row backwards and forwards between the rock and the tender at every tide, which in rough weather was a very heavy pull, and having often after that to work on the rock knee deep in water, only quitting it for the boats when absolutely compelled by the swelling waves. Sometimes the sea would be so fierce for days together that no boat could live in it, and the men had, therefore, to remain cooped up wearily on board the floating barrack.

One day in September, when the engineer and thirty-one men were on the rock, the tender broke from its moorings, and began to drift away from the rock, just as the tide was rising. Mr. Stevenson, perched on an eminence above the rest, surveying them at their labours, was the first, and for a while, the men being all intent on their work, the only one, who observed what had happened. He said nothing,

but went to the highest point of the rock, and kept an anxious watch on the progress of the vessel and the rising of the sea. First the men on the lower tier of the works, then by degrees those above them, struck work on the approach of the water. They gathered up their tools and made towards the spot where the boats were moored, to get their jackets and stockings and prepare for quitting the rock. What their feelings were when they found only a couple of boats there, and the tender drifting off with the other in tow, may be conceived. All the peril of their situation must have flashed across their minds as they looked across the raging sea, and saw the distance between the tender and the rock increasing every moment, while all around them the water rose higher and higher. In another hour, the waves would be rolling twelve feet and more above the crag on which they stood, and all hope of the tender being able to work round to them was being quickly dissipated. They watched the fleeting vessel and the rising tide, and their hearts sank within them, but not a word was uttered. They stood silently counting their numbers and calculating the capacity of the boats; and then they turned their eyes upon their trusted leader, as if their last hope lay in his counsel. Stevenson never forgot the appalling solemnity of the moment. One chance, and but a slender one, of escape alone occurred to him. It was that, stripping themselves of their

clothes, and divesting the two boats, as much as possible, of everything that weighted and encumbered them, so many men should take their seats in the boats, while the others hung on by the gunwales; and that they should then work their way, as best they could, towards either the tender or the floating barrack. Stevenson was about to explain this to his men, but found that all power of speech had left him. The anxiety of that dreadful moment had parched his throat, and his tongue clave to the roof of his mouth. He stooped to one of the little pools at his feet to moisten his fevered lips with the salt water. Suddenly a shout was raised, "A boat! A boat!" and through the haze a large pilot boat could dimly be discerned making towards the rock. The pilot had observed the *Smeaton* drifting off, and, guessing at once the critical position of the workmen on the rock, had hastened to their relief.

Next morning when the bell sounded on board the barrack for the return to the rock, only eight out of the twenty-six workmen, beside the foreman and seamen, made their appearance on deck to accompany their leader. Mr. Stevenson saw it would be useless to argue with them then. So he made no remark, and proceeded with the eight willing workmen to the rock, where they spent four hours at work. On returning to the barrack, the eighteen men who had remained on board appeared quite ashamed of their cowardice; and without a word being said to them,

were the first to take their places in the boats when the bell rang again in the afternoon.

At length the barrack was completed, and the men were then relieved from the toil of rowing backwards and forwards between the tender and the rock, as well as from the constant sickness which tormented them on board the floating barrack. They were now able to prolong their labours, when the tide permitted, into the night. At such times the rock assumed a singularly picturesque and romantic aspect —its surface crowded with men in all variety of attitudes, the two forges and numerous torches lighting up the scene, and throwing a lurid gleam across the waters, and the loud dong of the anvils mingling with the dashing of the breakers.

On the 18th July 1808, the site having been properly excavated, the first stone of the lighthouse was laid by the Duke of Argyle; and by the end of the second season some five or six feet of building had been erected, and were left to the mercy of the waves till the ensuing spring. The third season's operations raised the masonry to a height of thirty feet above the sea, and the fourth season saw the completion of the tower. On the first night in February of the succeeding year (1811) the lamp was lit, and beamed forth across the waters.

The Bell Rock Tower is 100 feet in height, 42 feet in diameter at the base, and 15 feet at the top. The door is 30 feet from the base, and the ascent is by

a massive bronze ladder. The "light" is revolving, and presents a white and red light alternately, by means of shades of red glass arranged in a frame. The machinery which causes the revolution of the lamp is also applied to the tolling of two large bells, in order to give warning to the mariner of his approach to the rock in foggy weather, thus reviving the traditional practice from which the rock takes its name.

III.—THE SKERRYVORE.

"Having crept upon deck about four in the morning, I find we are beating to windward off the Isle of Tyree, with the determination on the part of Mr. Stevenson that his constituents should visit a reef of rocks called Skerry Vhor, where he thought it would be essential to have a lighthouse. Loud remonstrances on the part of the commissioners, who one and all declare they will subscribe to his opinion, whatever it may be, rather than continue this dreadful buffeting. Quiet perseverance on the part of Mr. Stevenson, and great kicking, bouncing, and squabbling upon that of the yacht, who seems to like the idea of Skerry Vhor as little as the commissioners. At length, by dint of exertion, came in sight of this long range of rocks (chiefly under water), on which the tide breaks in a most tremendous style. There appear a few low broad rocks at one end of the reef which is about a mile in length. These are never

entirely under water, though the surf dashes over them. We took possession of it in the name of the commissioners, and generously bestowed our own great names on its crags and creeks. The rock was carefully measured by Mr. Stevenson. It will be a most desolate position for a lighthouse—the Bell Rock and Eddystone a joke to it, for the nearest land is the wild island of Tyree, at 14 miles distance."

Such is an entry in the diary of Sir Walter Scott's Yacht Tour, on the 27th August 1814; but although the necessity of a lighthouse on the Skerry Vhor, or, as it is now generally called, Skerryvore, was fully acknowledged by the authorities, it was not till twenty-four years afterwards that the undertaking was actually commenced, under the superintendence of Mr. Alan Stevenson, the son of the eminent engineer who erected the Bell Rock Lighthouse.

In the execution of this great work, if the son had, as compared with his father, certain advantages in his favour, he had also various disadvantages to contend with at Skerryvore from which the engineer of the Bell Rock was free. Mr. Alan Stevenson had steam power at his command, and the benefit of all the experience derived from the experiments of his predecessors in similar operations; but at the same time, the rock on which he had to work was at a greater distance from the land, and separated from it by a more dangerous passage than that of either the Bell or the Eddystone; and the geological

formation of which the rock is composed, was much more difficult to work upon. The Skerryvore is distant from Tyree, the nearest inhabited island, about 11 miles; even in fine weather the intervening passage is a trying one, and in rough weather no ship can live in such a sea, studded as it is with treacherous rocks. The sandstone of the Bell Rock is worn into rugged inequalities, which favoured the operations of the engineer; but the action of the waves on the igneous formation of the Skerryvore has given it all the smoothness and slippery polish of a mass of dark coloured glass. Indeed, the foreman of the masons, on first visiting the rock, not unjustly compared the operation of ascending it to that of "climbing up the neck of a bottle."

The 7th August 1838 was the first day of entire work on the rock, and with succeeding ones was spent in the erection of a temporary barrack of wood, for the men to lodge in on the rock. It was completed before the season closed; but one of the first heavy gales in November wrenched it from its holdings, and swept it into the sea, leaving nothing to mark the site but a few broken and twisted stanchions, attached to one of which was a portion of a great beam which had been shaken and rent, by dashing against the rocks, into a bundle of ribands. Thus in one night were obliterated the results of a whole season's toil, and with them, the hopes the men cherished of having a dwelling on the rock, instead of on board

the brig, where they suffered intensely from the miseries of constant sickness.

The excavation of the foundations occupied the whole of the summer season of 1839, from the 6th May to the 3d September. The hard, nitrified rock held out stoutly against the assaults of both iron and gunpowder; and much time was spent in hollowing out the basin in which the lighthouse was to be fixed. From the limited extent of the rock and the absence of any place of shelter, the blasting was an operation of considerable danger, as the men had no place to run to, and it had to be managed with great caution. Only a small portion of the rock could be blown up at a time, and care had to be taken to cover the part over with mats and nettings made of old rope to check the flight of the stones. The excavation of the flinty mass occupied nearly two summers.

The operations of 1840 included, much to the delight of the workmen, the reconstruction of the barrack, to which they were glad to remove from the tossing vessel. The second edifice was more substantial than the first, and proved more enduring. Rude and narrow as it was, it offered, after the discomforts of the vessel, almost a luxurious lodging to its hardy inmates.

"Packed 40 feet above the weather-beaten rock, in this singular abode," writes the engineer, Mr. Alan Stevenson, "with a goodly company of thirty

men, I have spent many a weary day and night, at those times when the sea prevented any one going down to the rock, anxiously looking for supplies from the shore, and earnestly longing for a change of weather favourable to the recommencement of the works. For miles around nothing could be seen but white foaming breakers, and nothing heard but howling winds and lashing waves. Our slumbers, too, were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the doors and windows; symptoms which, to one suddenly aroused from sound sleep, recalled the appalling fate of the former barrack, which had been engulphed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate. On two occasions in particular, these sensations were so vivid as to cause almost every one to spring out of bed; and some of the men fled from the barrack by a temporary gangway to the more stable, but less comfortable shelter afforded by the bare walls of the lighthouse tower, then unfinished, where they spent the remainder of the night in the darkness and the cold."

In spite of their anxiety to get on with the work, and their intrepidity in availing themselves of every opportunity, these gallant men were often forced by stress of weather into an inactivity which we may be sure they felt sadly irksome and against the

grain. "At such seasons," says Mr. Stevenson, "much of our time was spent in bed, for there alone we had effectual shelter from the winds and the spray which reached every cranny in the walls of our barrack." On one occasion they were for fourteen days without communication with the shore, and when at length the seas subsided, and they were able to make the signal to Tyree that a landing at the rock was practicable, scarcely twenty-four hours' stock of provisions remained on the rock. In spite of hardships and perils, however, the engineer declares that "life on the Skerryvore Rock was by no means destitute of its peculiar pleasures. The grandeur of the ocean's rage—the deep murmur of the waves—the hoarse cry of the sea birds, which wheeled continually over us, especially at our meals—the low moaning of the wind—or the gorgeous brightness of a glossy sea and a cloudless sky—and the solemn stillness of a deep blue vault, studded with stars, or cheered by the splendours of the full moon,—were the phases of external things that often arrested our thoughts in a situation where, with all the bustle that sometimes prevailed, there was necessarily so much time for reflection. Those changes, together with the continual succession of hopes and fears connected with the important work in which we were engaged, and the oft recurring calls for advice or direction, as well as occasional hours devoted to reading and correspondence, and the pleasures of

news from home, were more than sufficient to reconcile me to—nay, to make me really enjoy—an uninterrupted residence, on one occasion, of not less than five weeks on that desert rock."

The Skerryvore Lighthouse was at length successfully completed. The height of the tower is 138 feet 6 inches, of which the first 26 feet is solid. It contains a mass of stone work of more than double the quantity of the Bell Rock, and nearly five times that of the Eddystone. The entire cost, including steam tug and the building of a small harbour at Hynish for the reception of the little vessel that now attends the lighthouse, was £86,977. The light is revolving, and reaches its brightest state once every minute. It is produced by the revolution of eight great annular lenses around a central light, with four wicks, and can be seen from the deck of a vessel at the distance of 18 miles. Mr. Alan Stevenson sums up his deeply interesting narrative in the following words: "In such a situation as the Skerryvore, innumerable delays and disappointments were to be expected by those engaged in the work; and the entire loss of the fruit of the first season's labour in the course of a few hours, was a good lesson in the school of patience, and of trust in something better then an arm of flesh. During our progress, also, cranes and other materials were swept away by the waves; vessels were driven by sudden gales to seek shelter at a distance from the rocky shores

of Mull and Tyree; and the workmen were left on the rock desponding and idle, and destitute of many of the comforts with which a more roomy and sheltered dwelling, in the neighbourhood of friends, is generally connected. Daily risks were run in landing on the rock in a heavy surf, in blasting the splintery gneiss, or by the falling of heavy bodies from the tower on a narrow space below, to which so many persons were necessarily confined. Yet had we not any loss of either life or limb; and although our labours were prolonged from dawn to night, and our provisions were chiefly salt, the health of the people, with the exception of a few slight cases of dysentery, was generally good throughout the six successive summers of our sojourn on the rock. The close of the work was welcomed with thankfulness by all engaged in it; and our remarkable preservation was viewed, even by many of the most thoughtless, as, in a peculiar manner, the gracious work of Him by whom the very hairs of our heads are all numbered!"

Steam Navigation.

I.—JAMES SYMINGTON.
II.—ROBERT FULTON.
III.—HENRY BELL.
IV.—OCEAN STEAMERS.

Steam Navigation.

I.—JAMES SYMINGTON.

Of the many triumphs of enterprise achieved by the agency of that tremendous power which James Watt tamed and put in harness for his race, perhaps the greatest and most momentous is that which has reversed the old proverb, that "time and tide wait for no man," given ten-fold meaning to the truth that "seas but join the regions they divide," and enabled our ships to dash across the trackless deep in spite of opposing elements,—

> "Against wind, against tide,
> Steadying with upright keel,"

in a fraction of the time, and with a fraction of the cost and peril of the old mode of naval locomotion. How amply realized has been James Bell's prediction more than half a century ago, "I will venture to affirm that history does not afford an instance of such rapid improvement in commerce and civilization, as that which will be effected by steam vessels!"

Towards the close of the last century, a number of ingenious minds were in travail with the scheme of steam navigation. The Marquis de Jouffroy in France, and Fitch and Rumsey in America, were successful in experiments of its feasibility; but it is

to the efforts of Miller and Symington in Scotland, followed up by those of Fulton and Bell, that we are chiefly and more immediately indebted for the practical development of the project.

Having a natural bent for mechanical contrivances, and abundance of leisure and money to indulge his tastes, Mr. Miller of Dalswinton, in Dumfriesshire, somewhere about the year 1785, was full of schemes for driving ships by means of paddle-wheels,—by no means a novel idea, for it was known to the Romans, if not to the Egyptians, and had often been tried before.

All he aimed at originally was, to turn the wheels by the power of men or horses; and this he managed to do successfully enough. Single, double, and treble boats were often to be seen driving along Dalswinton Lake, moved by paddle-wheels instead of oars. On one occasion, at Leith, one of the double boats, sixty feet long, propelled by two wheels, each of which was turned by a couple of men, was matched against a Custom-house boat, which was reckoned a fast sailer. The paddle-wheels did duty very well; but the men were soon knocked up with turning them, and the want of some other motive power was strongly felt. A young man named Taylor, who was tutor to Mr. Miller's boys, is said to have suggested the use of steam; but whether this be so or not, it was not till Miller met with James Symington that the idea assumed a practical form.

In 1786 James Symington, then joint-engineer with his brother George, to the Wanlockhead Mines, was struck with the idea which, as we have seen, several other ingenious minds were also busy with about the same time,—of rendering the steam-engine available for locomotion both on land and sea. After much study and reflection, he succeeded in embodying the idea in a working model. It was supported on four wheels, which were moved in any direction by means of a small steam-engine, and could carry 16 cwt., besides coals, water, &c. It was exhibited in Edinburgh in the summer of 1786, and made a considerable sensation. Mr. Miller, fond of all such inventions, did not fail to get a sight of Symington's locomotive engine, the first time he was in town. He was delighted with its ingenuity and completeness, and procured an interview with the author. Of course, Miller was full of his own experiments, and told Symington the whole story of his efforts to propel vessels by paddle-wheels, and the want of some stronger, and more constant power than that of men to turn the capstan, upon which the motion of the wheels depended. Symington at once expressed the opinion he had formed,—that steam was equally available for vessels as for carriages, and showed him how the steam-engine which he had devised for his locomotive could be applied to the paddle-wheels. Miller was so much struck by his statements, which he illustrated by

reference to the model, that he determined to have an engine made on the same plan, and fitted into one of his double boats. Accordingly, an engine was built under Symington's directions and superintendence, sent to Dalswinton, and put together in October 1788. The engine, in a strong oak frame, was placed in the one half of a double pleasure-boat, the boiler occupying the other half, and the paddle-wheels being fixed in the middle.

The autumn was withering into winter, the yellow leaves were swirling to the ground with every little breath of wind, and the boughs were beginning to show forth bare and grim, when the little boat was launched upon the bosom of Dalswinton Loch. At length all the preparations were finished, and on the 14th November Mr. Miller had the delight of seeing the vessel gliding over the mimic waves of the lake at the rate of five miles an hour. The company on board the boat on that memorable occasion were—Mr. Miller himself, of course, nervous with pleasure and exultation; Taylor, the tutor; Alexander Nasmyth (the well-known landscape painter, and father of the man who, in the next generation, was to invent the wonderful steam-hammer, that knocks masses of iron about like putty, and can yet so moderate its force as to crack a nut without bruising the kernel); a brisk stripling with strongly marked features, by name Harry Brougham, afterwards to be Lord Chancellor of England, and perhaps the most

many-sided genius of his time; and — last and greatest of the group—there was one of Mr. Miller's tenants, the farmer of Ellisland,—Robert Burns, the great bard of Scotland, enjoying to the full, no doubt, the novelty of the expedition, but, we must suppose, unconscious of its import and grand future consequences, since he has accorded it no commemorative verse. "Many a time," says Mr. James Nasmyth, son of the distinguished painter, "I have heard my father describe the delight which this first and successful essay at steam navigation yielded the party in question. I only wish Burns had immortalized it in fit, clinking rhyme, for, indeed, it was a subject worthy of his highest muse."

The experiment was next tried on a large scale with a canal boat, on the Forth and Clyde Canal, but one of the wheels broke. Not to be balked, Symington had stronger wheels made, and the next time the steam was put on, the vessel went off at the rate of seven miles an hour. The experiment was several times repeated with success. The vessel, however, was so slight, that many more trips would have knocked it to pieces; and it was therefore dismantled. The fitting up of these vessels, and the working of them, formed a heavy drain upon Mr. Miller's purse; and having laid satisfactory proof before the world that the thing could be done, he relinquished the enterprise, and left it to be worked out by others. Just then, however, no one

came forward to fill his place; and for some years the idea slumbered.

In 1801 Symington could not afford to indulge in further efforts at his own expense, but he found a patron in Lord Dundas, who commissioned him to construct a steam-tug for dragging canal boats. A stout, serviceable tug was built; and a series of experiments entered upon to test her efficiency, which cost upwards of £3000. One bleak, stormy spring-day in 1802, the people on the banks of the Forth and Clyde Canal might have been seen staring with wonder, at the short, stumpy little tug pushing gallantly on at the rate of three or four miles an hour, with a strong wind right in her teeth, that no other vessel could make head against, and two loaded vessels (each of more than 70 tons burden) in tow. By itself, the tug could do six miles an hour without any great strain. The company made some objection, however, about the banks of the canal being injured, and the tug fell into disuse. It served an important end, though, in giving both Fulton and Bell a basis for their operations, and must be considered the parent of our modern steam-craft.

II.—ROBERT FULTON.

After Dr. Cartwright, the inventor of the power-loom, had retired penniless from his manufacturing enterprises, and had taken up his abode in London,

one of the constant visitors at his modest residence in Marylebone Fields, was a thin, sharp-featured American, about twenty-eight years of age, an artist by profession, and formerly student of Benjamin West, who, however, was now much more interested in the art of engineering than the art of painting. From an early age he had shown a taste for mechanics, and was fond of spending his play-hours at school loitering about workshops and factories, watching the men at their work, and studying the machines and instruments they used. This sojourn in England had brought him into contact with the Duke of Bridgewater, the great canal projector, and Lord Stanhope, well known for his improvements in the printing press and other contrivances, in whose company his boyish bent towards mechanics was revived, and became quite a passion with him. He threw aside his brushes and palette, and applied himself to his favourite pursuit with heart and soul. Having formed the acquaintance of Cartwright, he became a daily visitor at his house, and the enthusiastic, good-natured doctor and he would sit debating for hours the great problem: "Whether it were practicable to move vessels by steam?" Fulton, eager, restless, vivacious, with pencil in hand, was perpetually sketching plans of paddle-wheels; while the doctor, calm, dignified, and earnest, equally engrossed in the subject, was contriving various modes of bringing steam to act upon them. Neither of them

had any doubt that the thing could be done, but the "how" long baffled them; and even though the doctor constructed "the model of a boat, which, being wound up like a clock, moved on the water in a highly satisfactory manner," nothing practical came of their cogitations till some years after.

While on a visit to Paris, Fulton was struck with the injury which standing navies of men-of-war inflicted on the mercantile marine, and gave his whole attention, as he says, "to find out the means of destroying such engines of oppression, by some method which would put it out of the power of any nation to maintain such a system, and compel every government to adopt the simple principles of education, industry, and a free circulation of its produce." The means presented itself to his mind in the shape of an explosive shell, called the torpedo, by which any ship of war could be blown to pieces; and for six or seven years he occupied himself in fruitless attempts to get first the government of France, and then that of England, to take up his project. He did not abandon his schemes with regard to steam-vessels, however; but, under the auspices of Mr. Livingstone, the American ambassador, made several experiments. One vessel of considerable size broke through the middle when the engines were placed on board, but a second one was rather more successful, though but a slow rate of movement was attained. His project came under the notice of

Napoleon, then First Consul, who did not fail to appreciate its value. "It was," he said, "capable of changing the face of the world;" and he directed a commission to inquire into its merits. Nothing came of it, however.

Shortly after, Fulton visited Scotland, and got an introduction to Symington, whom he pressed for a sight of his boat. Symington generously consented, and gave him a short sail on board the steam-tug. Fulton made no concealment of his intention of starting steamboats in his own country, whither he was about to return, and asked Symington to allow him to make a few notes of his observations on board. Symington had no objections; and, therefore, he says, "Fulton pulled out a memorandum book, and after putting several pointed questions respecting the general construction and effect of the machine, which I answered in a most explicit manner, he jotted down particularly everything then described, with his own remarks upon the boat while moving with him on board along the canal." Fulton was very liberal in his promises not to forget his assistance, if he got steamboats established in America; but Symington never heard anything more of him.

Fulton was at New York in 1806, and busy getting a steamboat put together. It was a costly undertaking, and he had little spare cash of his own; so he offered shares in the concern to his friends, but no one would have anything to do with so ridiculous

a scheme, as they thought. "My friends," says Fulton, "were civil, but shy. They listened with patience to my explanations, but with a settled cast of incredulity on their countenances. I felt the full force of the lamentation of the poet,—

> 'Truths would you teach, to save a sinking land,
> All shun, none aid you, and few understand.'

As I had occasion to pass daily to and from the building-yard while my boat was in progress, I have often loitered, unknown, near the idle groups of strangers, gathering in little circles, and heard various inquiries as to the object of this new vehicle. The language was uniformly that of scorn, sneer, or ridicule. The loud laugh rose at my expense, the dry jest, the wise calculation of losses and expenditure, the dull, but endless repetition of 'the Fulton Folly.' Never did a single encouraging remark, a bright hope, or a warm wish, cross my path."

Let them laugh that win. The success which shortly attended Fulton's scheme turned the tables upon those who had mocked at him. The *Clermont* was completed in August 1807, and the day arrived when the trial was to be made on the Hudson river. "To me," wrote Fulton, "it was a most trying and interesting occasion. I wanted some friends to go on board to witness the first successful trip. Many of them did me the favour to attend as a mark of personal respect; but it was manifest they did it with reluctance, fearing to be

partners of my mortification, and not of my triumph. The moment arrived in which the word was to be given for the vessel to move. My friends were in groups on the deck. There was anxiety mixed with fear among them. They were silent, sad, and weary. I read in their looks nothing but disaster, and almost repented of my efforts. The signal was given, and the boat moved on a short distance, and then stopped and became immovable. To the silence of the preceding moment now succeeded murmurs of discontent and agitation, and whispers and shrugs. I could hear distinctly repeated—'I told you so; it is a foolish scheme; I wish we were well out of it.' I elevated myself on a platform, and stated that I knew not what was the matter; but if they would be quiet, and indulge me for half an hour, I would either go on or abandon the voyage. I went below, and discovered that a slight misadjustment was the cause. It was obviated. The boat went on; we left New York; we passed through the Highlands; we reached Albany! Yet even their imagination superseded the force of fact. It was doubted if it could be done again, or if it could be made, in any case, of any great value."

The simple-minded country folk on the banks of the Hudson were almost frightened out of their wits at the awful apparition which they saw gliding along the river, and which, especially when seen indistinctly looming through the night, looked to their bewildered

eyes, "a monster moving on the water, defying the winds and tide, and breathing flames and smoke." Pine-wood was used for fuel, and whenever the fire was stirred, a great burst of sparks issued from the chimney. "This uncommon light," says Colden, the biographer of Fulton, "first attracted the attention of the crews of other vessels. Notwithstanding the wind and tide were adverse to its approach, they saw with astonishment that it was rapidly coming towards them; and when it came so near that the noise of the machinery and paddles were heard, the crews in some instances shrunk beneath their decks from the terrific sight, and others left their vessels to go on shore; while others, again, prostrated themselves, and besought Providence to protect them from the approach of the horrible monster which was marching on the tides, and lighting its path by the fires which it vomited."

With the novelty of the spectacle its terror died away, and people soon got tired of rushing out to see the remarkable machine that had once seemed so miraculous to them. The *Clermont* soon began to travel regularly as a passage-boat between Albany and New York, other steam-vessels were constructed on its model, and by degrees the steam marine of America grew into the host it is at present. Thirty years after the first experiment on the Hudson, it was calculated 1300 steamboats had been built in the States.

Fulton did not live long to enjoy his triumphs. He died in 1815, having been actively engaged in promoting steam navigation to his last hours.

III.—HENRY BELL.

The honour which in America attached to Fulton as the man who first brought the steamboat into use, and to the River Hudson as being the scene of the experiment, in our own country fell (in a somewhat less degree, being subsequent), to Henry Bell, and the River Clyde.

Brought up as a millwright, Bell, from want of funds to start in business, was obliged for many years to gain his living as a common carpenter in Glasgow, where he was noted among the trade as being very fond of "schemes," and suspected on that account by narrow-minded folk of being not very reliable in the lower branches of his craft. Scheme after scheme issued from his fertile mind; but he was rash and hasty in working them out, and few proved of much worth. Steam navigation being one of the vexed problems of the time, had every fascination for his peculiar genius; and he seems to have been brooding over it as the last century was closing, and the present opening upon the world. When Fulton visited Symington's invention, Bell appears to have accompanied him, and to have afterwards corresponded with him on the subject. "This," he says, "led me to think of the absurdity of writing

my opinions to other countries, and not putting it in practice myself in my own country; and from these considerations I was roused to set on foot a steamboat, for which I made a number of different models before I was satisfied." Having removed to the little village of Helensburgh, on the banks of the Clyde, and there established a hotel and bath-house, which his wife managed, he endeavoured to work the passage-boats by which visitors were brought to the place, by means of paddle-wheels worked by the hand, instead of oars; but the plan did not succeed very well, for the same reason that led to Mr. Miller's abandonment of it—the inefficiency of manual power, which could not be applied with sufficiently sustained and continuous force. He therefore gave it up, and turned his attention to the employment of steam power for the same purpose. Of course, he was laughed at for his pains; and Henry Bell's project for having steamers on the Clyde became a standing joke among the frequenters of the watering-place. Even after the permanent success of Fulton's scheme was known, people would not moderate their incredulity; but Bell's faith, which had never wavered, was now confirmed, and he set about the work with redoubled energy.

In 1811, Bell, having procured the necessary funds, had a steam-boat built of twenty-five tons and four horse power. He named it the *Comet*, because a comet had just then appeared in the

north-west of Scotland. The *Comet* began to run regularly between Glasgow and Helensburgh in January 1812, and continued to ply successfully during the summer of that year. At first, however, she brought rather loss than gain to her projector. People were shy of trusting themselves on board, and parties interested in the stage-coaches and sailing vessels, spread all sorts of absurd reports about her. It was not till she had gone for some time without accident, that tourists began to think they might as well save their money and their time by patronizing the new mode of conveyance. In the second year Bell took the *Comet* off the Clyde, and sent her on a tour round the open coasts of the three kingdoms. Before long the safety and utility of steam navigation was admitted on all hands, and numerous rival enterprises were on foot. In 1820 the *Comet* was lost between Glasgow and Fort William; and in the following year another of Bell's vessels was burnt to the water-edge—two misfortunes that carried £3000 out of his pocket. His rivals, with abundant capital, soon drove him out of the field, and Bell sank into poverty and neglect. A small annuity from the Clyde trustees, and a subscription among his friends, to keep him from starving, were all the rewards he ever received for his enterprise and perseverance. He died in 1830 in the sixty-fourth year of his age.

IV.—OCEAN STEAMERS.

In the quarter of a century which elapsed between 1812, when the *Comet* first began to churn the waters of the Clyde, and 1837, steam navigation progressed steadily and surely. At first, content with plying along rivers and quiet bays, steamers by-and-by ventured out upon the open sea. We owe the regular establishment of deep-sea packets to the courage and enterprise of Mr. David Napier of Glasgow, "who," says Mr. Scott Russell, "has effected more for the improvement of steam navigation than any other man." He was quick to appreciate the capabilities of steam-vessels, and saw that they were fit for something more than mere inland voyages. Before starting one of them upon the open sea, however, he carefully estimated the danger to be encountered and the difficulties to be overcome. He took passage at the worst season of the year in one of the sailing vessels which formerly plied between Glasgow and Belfast, and which often required a week to perform a journey that is now done by steam in a few hours.

Stationing himself on an elevated part of the deck, he kept a close watch on the movements of the vessel, observing the tossing to which she was subjected by the waves, the extent of the dip when she sank into a trough, the height of elevation when lifted on the summit of a wave, and calculating in his mind

how all this would tell on the paddle-wheels Through the roughest of the storm, when the vessel was pitching worst, and the wind blowing at its fiercest, he kept his place on deck, regardless of the drenching spray and the blast that almost carried him off his legs. When at length he had satisfied himself by the observation of his own eyes and inquiries of the captain and crew, that there was nothing in the voyage which a steamer could not encounter, he retired contentedly to his cabin, leaving everybody astonished at his strange curiosity respecting the effect of rough weather on the ship.

Not long after David Napier started the *Rob Roy* steam-packet between Greenock and Belfast, and afterwards between Dover and Calais. In the course of two or three years more he had established steam communication between Holyhead and Dublin, Liverpool and Greenock, and various other parts. The length of each unbroken passage was then considered the great difficulty; but as steamers got improved both in form and machinery, passages of greater length were successfully accomplished. Steamers traversed in all directions the German Ocean, the Mediterranean, the Baltic, and, in short, all the waters on the eastern side of the Atlantic; and were in use upon all the rivers and lakes of any size in Europe.

At length, in 1836, the startling project was set on foot of superseding the far-famed New York and

Liverpool packet ships by a fleet of steam-ships. Before this the *Savannah*, a steam vessel of 300 tons, had, in 1819, crossed from New York to Liverpool in twenty-six days, partly with sails and partly with steam; and another steam vessel had, in 1825, made the voyage from England to Calcutta; but one swallow does not make a summer, and many learned folks, on both sides of the Atlantic, shook their heads doubtfully at the daring scheme of regular steam communication across 13,000 miles of ocean. The experiment was to be made, however; and on the 4th April 1838, the *Sirius*, of 700 tons and 320 horse power, sailed from Cork for the far West. Four days after the *Great Western* followed in her wake from Bristol.

Great was the excitement in New York as the time drew nigh when the *Sirius* was considered due. For days together the Battery was crowded with anxious watchers, from the first breaking of the cold, grey dawn till night dropped its dark curtain on the scene. At that time a telescope was a thing to be begged, borrowed, or stolen,—to be got, somehow or other, if only for a minute,—and a man who possessed one was to be looked up to, made much of, and, if possible, coaxed out of the loan of it. All day long a hundred telescopes swept the sea. The ocean steamer was the great topic of the hour, and "any appearance of her?" the constant question when two people met. On St. George's day, the 23d April, a

dim, dusky speck on the far horizon grew under the eye of the thousands of breathless watchers into a long train of smoke, beneath which, as the hours wore on, appeared the black prow of a huge steam-boat. There she was, long looked for come at last; and with the American colours at the fore, and the flag of Old England rustling at the stern, the *Sirius* swept into the harbour amidst the cheers of the multitude, the ringing of the city bells, and the firing of salutes. The excitement reached its climax, and the shouting and firing grew deafening, when, some few hours later on the same auspicious day, the *Great Western* came to anchor alongside of her rival.

Twenty-two years have passed since then, and the marvel of 1838 has become a mere everyday affair. There are some fourteen different lines of steamers, comprising more than fifty vessels, running between the United States and Europe, to say nothing of the magnificent steam fleets of the Peninsular and Oriental, the Royal West India, British and North American, Pacific, Australian, South Western, and other companies.

The employment of iron in the construction of ships, thus securing at once lightness and strength, and the invention of the screw propeller, in 1836, by Mr. J. P. Smith, a farmer at Hendon, by means of which a vessel can combine all the qualities of a first-rate sailing ship with the use of steam power, gave a great impulse to steam navigation, which is

still making steady and continuous progress. From one steam vessel in 1812 the number in the kingdom has risen successively to 20 in 1820, 824 in 1840, and over 2000 in 1860. During 1858, 153 steamers were built in the United Kingdom, of which 112 were of iron. It is interesting to observe the advance in size of the steam vessels from their first introduction on the Clyde.

	Length.	Breadth.
1812. Comet	40 feet	10½ feet.
1825. Enterprise, (built expressly to go to India, coaling at intermediate stations)	122 „	27 „
1835. Tagus (for Mediterranean)	182 „	28 „
1838. Great Western (the first ship built expressly for Transatlantic service)	236 „	35½ „
1844. Great Britain (the first large screw ship, and largest iron ship up to that time)	322 „	51 „
1853. Himalaya (iron)	370 „	43½ „
1856. Persia (do.)	390 „	45 „
1859. Great Eastern (do.)	680 „	83 „

In the interval between 1812 and 1870 the number of steamers in the United Kingdom has increased from one to nearly three thousand; and the ocean-going steamer of 1870 is nearly six times the length of that of 1825, and seventeen times the length of the *Comet*, while the difference in tonnage is still greater. How Fulton or Bell would open their eyes at the sight of a vast moving city, such as the Big Ship, an eighth of a mile in length, propelled by both paddle-wheels and screw, each worked by four huge engines!

Iron Manufacture.

HENRY CORT.

Iron Manufacture.

HENRY CORT.

THE multifarious use of iron in our day has given its name to the age. We have got far beyond the primitive applications of that metal—every day it is supplanting some other substance, and there is no saying where the wide-spread and varied service we exact from it will stop. The invention of the steam-engine, and the improvement of manufacturing machines, would be comparatively valueless, unless we had at command a cheap and abundant supply of iron for their construction. The land is covered with a net-work of iron rails, traversed by iron steeds—gulfs and valleys are spanned by iron arches and iron tubes—huge ships of iron ride upon the deep. Even stones and bricks are being discarded for this all-useful substance, and of iron we are building houses, palaces, theatres, churches, and spacious domes. There is no end to its uses.

And yet, it is only between seventy and eighty years ago since Britain, the richest of all countries in native ore, was dependent upon others for her supply of the manufactured metal. We wanted but little iron in those days, compared with the present demand, and yet that little we could not furnish

ourselves with. As much as a million and a half a-year went out of our pockets to purchase wrought iron from Sweden alone, and we were good customers to Russia as well. All the iron that our country could then produce was some 17,000 tons. The man who showed us how to turn our own ore to account, who rendered us independent of all other countries for our supply, and made us the great purveyors of wrought iron to the world, who opened up to us this great source of national wealth, was Henry Cort of Gosport.

The great difficulty which he solved was how to get wrought iron out of the crude iron as it came from the smelting furnace, without using charcoal. With but a small tract of country, densely peopled, we had but a scant supply of wood at our command. The great forests which once overspread the land were gradually vanishing, partly before the spread of population and the growth of towns, and partly from the inroads made on them by the demand for timber. Formerly, the first transformation of the ore into pig iron (the crude form of the manufactured metal) was effected by means of wood; and the consumption was so great that an Act was passed in 1581 restraining its use. Soon afterwards Lord Dudley discovered that coal would answer the purpose just as well, and obtained a patent of monopoly. He reaped but little profit from his invention, however, for his iron-works were destroyed by a mob; and it was not till a

century afterwards, when people got more alarmed at the growing scarcity of timber, and the increased demand for it, that the plan was generally adopted. This was one step in the right direction, but another yet remained to be made, for the manufacture was still hampered in our country by the want of wood for the second process—the conversion of crude into malleable iron, in which state alone it is fit for service.

About the year 1785, Henry Cort, iron-master, of Gosport, after many years of patient and wearisome research, of anxious thought, and indefatigable experiment, in which he spent a private fortune of some £20,000, perfected a couple of inventions of priceless value. The first was the process of converting pig iron into wrought iron by the flame of pit coal in a puddling furnace, thus dispensing with the use of charcoal,—the cost and scarcity of which had before formed such a dead weight on the trade, and placed us at such a disadvantage compared with Sweden and Russia. The second was a further process for drawing the iron into bars by means of grooved rollers. Till then, this operation had to be performed with hammer and anvil, and was very tedious and laborious. The new system not only reduced the cost and labour of producing iron to one-twentieth of what they were previously, but greatly improved the quality of the article produced.

It is not easy to estimate all that Henry Cort's inventions have done for this country. Without them we should have lost an overflowing and inexhaustible source of national wealth, and, moreover, large sums would have been taken out of the country in the purchase of wrought metal; we should never have been able to give full scope to the great mechanical inventions brought forth towards the close of the last, and the opening of the present century; we should have been debarred from taking rank as the great engineers and engine-makers for the rest of the world. The direct gain to this country from the inventions of Henry Cort, which enabled us to work up our own iron, has been calculated as equal by this time to not less than a hundred millions; and it is hardly possible to exaggerate the benefits which it has conferred. Lord Sheffield's prophecy, that the adoption of these processes would be worth more to Britain than a dozen colonies, may be said to have been fulfilled.

Like many another benefactor of his country, Cort got little good out of his invention for himself. He took out a patent for his process, and arranged with the leading iron-masters to accept a royalty of ten shillings a ton for the use of them. With a large fortune in prospect, his purse was just then exhausted by the expenses he had incurred in experiments and researches; and he had to look out for a capitalist to aid him in working the patent on his own account.

As ill luck would have it, he entered into partnership with a certain Adam Jellicoe, then deputy-paymaster of the navy. Jellicoe was considered a man of substance, and a "thoroughly respectable" character. He was to advance the ready money, and to receive in return half of the profits of the trade, Cort assigning to him, by way of collateral security, his patent rights. For a year or two all went well. The patent was everywhere adopted, and Cort's own iron works drove a lucrative and growing trade. He seemed in a fair way of getting back the fortune he had spent in bringing out the inventions, doubled or trebled, as he well deserved. The respectable Jellicoe was seized with a mortal sickness: at his death his desk was filled by another, his books were examined, and it turned out that he had been robbing the government for many a year back, and was a large defaulter. Cort, of course, had nothing to do with this villany, but he had to pay the penalty of it. As Jellicoe's partner he was responsible, in those days of unlimited liability, for all Jellicoe's debts; but that was not the worst of it. The treasurer of the navy was not content to exact only the payment of Jellicoe's defalcations, as he had no doubt a right to do, but confiscated the whole of Cort's patent rights, business, and property, which would have paid the debt seven or eight times over, had it been fairly valued.

This incident has never been properly cleared up,

but what glimpses of its secret passages have been obtained, seem to indicate clearly enough that poor Cort was the victim, not of one, but of two or more swindlers. To the day of his death he never could obtain a distinct account of the proceedings; and when, after his death, a Royal Commission was appointed to inquire into the matter, the treasurer of the navy and his deputy took care, a week or two before the Commission met, to indemnify each other by a joint release, and to burn their accounts for upwards of a million and a half of public money, for the application of which they were responsible, as well as all papers relating to Cort's case. When the Commission met, and the treasurer and his deputy were called before it, they refused to answer questions which would criminate themselves.

His connection with Jellicoe was, of course, the ruin of Henry Cort. He had no means of re-establishing himself in business; he was robbed of all income from his patents; and he died ruined and broken-hearted ten years after, leaving a family of nine children, without a sixpence in the world. Four of these children now survive—old, infirm, and indigent—only saved from being dependent upon parish bounty by pensions, amounting in the aggregate to £90 per annum. Well may it be said, "There should be more gratitude in our Iron Age to the children of HENRY CORT."

The Electric Telegraph.

I.—MR. COOKE.
II.—PROFESSOR WHEATSTONE.
III.—THE SUBMARINE TELEGRAPH.

The Electric Telegraph.

"Speak the word and think the thought,
Quick 'tis as with lightning caught—
Over, under lands or seas,
To the far antipodes;
Here again, as soon as gone,
Making all the earth as one;
Moscow speaks at twelve o'clock,—
London reads ere noon the shock."

I.—MR. COOKE.

Of all the marvels of our time, the most marvellous is the subjugation of the electric fluid, that potent elemental force,—twin brother of the fatal lightning,—to be our submissive courier, to bear our messages from land to land, and "put a girdle round about the earth in forty minutes." The Prospero that tamed this Ariel was no individual genius, but "two single gentlemen rolled into one." The idea of employing the electric current for the conveyance of signals between distant points, can be traced pretty far back in date; but to Mr. Cooke and Professor Wheatstone is undoubtedly due the credit of having made the electric telegraph an actual and accomplished fact, and rendered it practicable for everyday uses.

Having served for a number of years as an officer in our Indian army, Mr. Cooke came back to Europe to recruit his health in the beginning of 1836, and took up his abode at Heidelberg. He found agree-

able occupation for his leisure in the study of anatomy, and in the construction of anatomical models for his father's museum at Durham, where he was a professor in the university. Entirely self-taught in this delicate art, Mr. Cooke applied himself to it with characteristic ardour, and attained remarkable skill. One day he happened to witness some experiments which were made by Professor Möncke, to illustrate the feasibility of electric signalling. A current of electricity was passed through a long wire, and set a magnetic needle at the end quivering under its influence. The experiment was a very simple one, and not at all novel; but Cooke had never paid any attention to the subject before, and was much struck with what he saw. He became strongly impressed with the possibility of employing electricity in the transmission of telegraphic intelligence between distant places. From the day he witnessed the experiments in Professor Möncke's class-room, he forsook the dissecting knife, threw aside his modelling tools, and applied himself to the realization of his conception. With such ardour and devotion did he labour, and such skill and ingenuity did he bring to the work, that within three weeks he had constructed a telegraph with six wires, forming three complete metallic currents, and influencing three needles, by the varied inclination of which twenty-six different signals were designated. In that short time he had also invented the detector, by

which injuries to the wires, whether from water, fracture, or contact with substances capable of diverting the current, were readily traced, and the alarum, by which notice is given at one end of the wire that a message is coming from the other. Both these contrivances were of the utmost value,—indeed, without them electric telegraphy would be impracticable,—and are still in use. Possessing more of a mechanical than a scientific genius, Mr. Cooke bestowed more of his time and ingenuity on the perfection of a telegraph to be worked by clock mechanism, set in action by the withdrawal of a detent by an electro magnet than in the completion of the electric telegraph pure and simple.

Soon after having invented his telegraph, he came over to London, and spent the rest of the year in making a variety of instruments, and in efforts to get his telegraph introduced on the Liverpool and Manchester Railway. He found an obstacle to the complete success of his mechanical telegraph, in the difficulty of transmitting to a distance sufficient electric power to work the electro magnet upon which its action depended. A friend advised him to consult Professor Wheatstone, then known to be deeply engaged in electrical experiments, with a view to telegraphy; and accordingly, an interview between them took place in February 1837.

II.—PROFESSOR WHEATSTONE.

Mr. Charles Wheatstone, F.R.S., and Professor of Experimental Philosophy in King's College at the time of that interview, had made considerable advances in the scientific part of the enterprise. At the commencement of his career as a maker and seller of musical instruments in London, he was led to investigate the science of sound; and from his researches in that direction, he was led—much as Herschel was led—to devote himself to optics, and to study the philosophy of light. He was the first to point out the peculiarity of binocular vision, and to describe the stereoscope, which has since become so popular an instrument. Gradually, however, his thoughts and researches came to be steadfastly directed to the application of electricity to the communication of signals. In determining the rate at which the electric current travels through a wire he had laid down, he made an important stride towards the end in view. He proved by a series of most ingenious experiments, that one spark of electricity leaps on before another, and that its progress is a question of time. He found that electricity travels through a *copper* wire as fast as, if not faster, than light, that is, at the rate of 200,000 miles in a second; but through an *iron* wire, electricity moves at the rate of only 15,400 miles in a second. In 1836 Mr. Wheatstone had begun experiments in

the vaults of King's College, with four miles of wire, properly insulated, and was working out the details of a telegraph, the scientific principles of which he had already laid down. He had discovered an original method of converting a few wires into a considerable number of circuits, so that the greatest number of signals could be transmitted by a limited number of wires, by the deflection of magnetic needles. Mr. Wheatstone, however, was somewhat backward in the mechanical parts of the scheme, and the meeting between him and Cooke was therefore of the greatest benefit to both, and an admirable illustration of the old proverb, that two heads are better than one. Had they never been brought together, —had they kept on working out their own ideas apart—each would, no doubt, have been able to produce an electric telegraph; but a great deal of time would have been lost, and their respective efforts less complete and valuable than the one they effected in conjunction. Cooke wanted sound, scientific knowledge; Wheatstone wanted mechanical ingenuity; and their union supplied mutual deficiencies. A partnership was immediately formed between them. Before their combined genius all difficulties vanished; and in the June of the same year they were able to take out a patent for a telegraph with five wires and five needles. Their respective shares in its invention are clearly marked out by Sir J. Brunel and Professor Daniell, who, as arbiters be-

tween the two upon that delicate question, gave the following award in 1841 :—

"Whilst Mr. Cooke is entitled to stand alone as the gentleman to whom this country is indebted for having practically introduced and carried out the electric telegraph as a useful undertaking, promising to be a work of national importance; and Professor Wheatstone is acknowledged as the scientific man whose profound and successful researches had already prepared the public to receive it as a project capable of practical application,—it is to the united labours of two gentlemen so well qualified for mutual assistance, that we must attribute the rapid progress which this important invention has made during the five years since they have been associated."

Shortly after the taking out of a patent, wires were laid down between Euston Square Terminus and Camden Town Station, on the North-Western Railway; and the new telegraph was subjected to trial. Late in the evening of the 25th July 1837, in a dingy little room in one of the Euston Square offices, Professor Wheatstone sat alone, with a hand on each handle of the signal instrument, and an anxious eye upon the dial, with its needles as yet in motionless repose. In another little room at the Camden Town Station, Mr. Cooke was seated in a similar position before the instrument at the other end of the wires, along with Mr., now Sir Charles

Fox, Robert Stephenson, and some other gentlemen. It was a trying, agitating moment for the two inventors,—how Wheatstone's pulse must have throbbed, and his heart beat, as he jerked the handle, broke the electric current, and sent the needles quivering on the dial; in what suspense he must have spent the next few minutes, holding his breath as though to hear his fellow's voice, and almost afraid to look at the dial lest no answer should be made; with what a thrill of joy must each have seen the needles wag knowingly and spell out their precious message, —the "All's well; thank God," that flashed from heart to heart, along the line of senseless wire. "Never," said Wheatstone, "did I feel such a tumultuous sensation before, as when all alone in the still room I heard the needles click; and as I spelled the words, I felt all the magnitude of the invention now proved to be practicable beyond cavil or dispute."

A few days before this trial of the telegraph in London, Steinheil, of Munich, is said to have had one of his own invention at work there; and it is a difficult question to decide whether he or Cooke and Wheatstone were the first inventors. It is, however, a question of no consequence, as each worked independently. Since the first English electric telegraph was patented, there have been a thousand and one other contrivances of a similar kind taken out; but it may be doubted whether, for practical purposes,

the original apparatus, with the improvements which its own inventors have made on it, is not still the best of them all.

From being used merely to carry railway messages, the telegraph was brought into the service of the general public; the advantages of such almost instantaneous communication were readily appreciated; and eight years after Messrs. Cooke and Wheatstone took out their patent, lines of telegraph to the extent of 500 miles were in operation in England upon the original plan. In 1855 telegraphic correspondence had become so general, that the Electric Telegraph Company was started to supply the demand. In that establishment the Needle Telegraph of Wheatstone and Cooke is the one generally used, with the Chemical Recording Telegraph of Bain for special occasions. By means of the latter, blue lines of various lengths, according to an alphabet, are drawn upon a ribbon of paper, and as many as 20,000 words can be sent in an hour, though the ordinary rate is 100 per minute. In the purchase of patent rights alone, the Company have spent £170,000, and they are every year adding to the length of their wires. In June 1850 they had 6730 miles of wires, and despatched 29,245 messages a year. In December 1853 they had 24,340 miles of wires, and despatched 212,440 messages a-year. Their lines now extend over a much larger mileage, and convey a greatly increased number of messages. The

Magnetic Telegraph Company have also a large extent of wires, and do a considerable business.

III.—THE SUBMARINE TELEGRAPH.

The land telegraph having had such success, the next step was to carry the wires across the deep, and link continent to continent,—an all-important step for an island kingdom such as ours, with its legion of distant colonies. The success of a submerged cable between Gosport and Portsmouth, and of one across the docks at Hull, proved the feasibility of a water telegraph, at least on a small scale, and it was not long before more ambitious attempts were made. On the 28th of August 1850, a cable, 30 miles long, in a gutta percha sheathing, was stretched at the bottom of the straits between Dover and Cape Grisnez, near Calais. Messages of congratulation sped along this wire between England and France; and although a ridge of rocks filed the cable asunder on the French coast, the suspension of communication was only temporary. The link has once more been established, and is in daily use. The first news sent by the wire to England was of the celebrated *coup d'etat* of the 2d December, which cleared the way for Louis Napoleon's ascent of the throne. Numerous other cables have since been sunk beneath the waters; complete telegraphic communication has just been established between England and India, and will, no doubt, before long be extended to Australia.

The greatest enterprise of this kind, however, still remains unaccomplished—that is, the laying of the Atlantic cable. A company was started in 1856 to carry out this great enterprise, the governments of Great Britain and the United States engaging to assist them, not only with an annual subsidy of £10,000 a-year for twenty-five years, but to furnish the men and ships required for laying the cable from one side of the Atlantic to the other. The chief difficulty which engaged the attention of Mr. Wildman Whitehouse and the other agents of the notable enterprise was the enormous size of the cable which, it was thought, would be necessary. The general belief at that time was, that the greater the distance to be traversed, the larger must be the wire along which the electric current was to pass, and that the rate of speed would be in proportion to the size of the conductor. Mr. Whitehouse, however, thought it would be as well to begin by making sure that this was really the case, and that a monster cable was essential; and after some three thousand separate observations and experiments, was delighted to find that the difficulty which stared them in the face was imaginary. Instead of a large cable transmitting the current faster than a small one, he ascertained beyond a doubt, that the bigger the wire, the slower was the passage of the electricity. It would be needful, therefore, to make the cable only strong enough to stand the strain of its own weight, and heavy enough to sink

to the bottom. A single wire would have been quite sufficient, but a strand of seven wires of the finest copper was used for the cable, so that the fracture of one of them might not interfere with the communication,—as long as one wire was left intact the current would proceed. A triple coating of gutta percha, to keep the sea from sucking out the electricity, and a thick coating of iron wire, to sink the cable to the bottom and give it strength, were added to the copper rope, and then the cable was complete. No less than 325,000 miles of iron and copper wire were woven into this great cable,—as much as might be wound thirteen times round the globe; and its weight was about a ton per mile. The length of the cable was 18,947 miles—some 600 miles being allowed to come and go upon, in case of accidents.

The end of July 1857 was selected for the sailing of the ships that were to lay the cable, as fogs and gales were then out of season, and no icebergs to be met with. On the 8th of August, the *Agamemnon* (English) and *Niagara* (American), with four smaller steamers to attend them, and each with half of the mighty cable in her hold, got up their steam and left Valentia Harbour. One end of the cable was carried by a number of boats from the *Niagara* on shore, where the Lord-Lieutenant was in waiting to receive it, and place it in contact with the batteries, which were arranged in a little tent upon the

beach. A slight accident to the cable for a little while delayed the departure of the ships; but by the 10th they had got 200 miles out to sea, and so far the cable had been laid successfully. Messages passed and repassed between the ships and the shore. The next day the engineer discovering that too much cable was being paid out, telegraphed to the people on board to put a greater grip on it; the operation was clumsily managed, and the cable snapped, sinking to a depth of 12,000 feet.

Not disheartened, however, the Company replaced the lost portion of the cable; the Government again furnished ships and men, and the cable was actually laid at the bottom of the Atlantic from Valentia Bay to Trinity Harbour.

Addresses of congratulation passed between the Queen and the President of the States, and numerous messages were transmitted. But gradually the signals grew fainter and more faint, till they ceased altogether. The cable was stricken dumb. A little to the north of the fiftieth parallel of latitude, at the bottom of the Atlantic, where the plateau is unbroken by any great depression, some 1500 miles of the disabled cable were lying, on a soft bed of mud, which was constantly thickening, at a depth of from 10,000 to 15,000 feet.

The importance of telegraphic communication between England and the United States was, however, so obvious that its projectors were not to be

daunted by the failure they had sustained. Nor was it altogether a failure. They had proved that a cable *could* be laid, and messages flashed through it. What was wanted was evidently a stronger cable, which should be less liable to injury, and more perfect in its insulation of the telegraphic wires.

From 1858 to 1864, the Company were engaged in the difficult task of raising fresh funds, and in endeavouring to secure grants from the British and American Governments. Their men of science, meanwhile, were devising improvements in the form of cable, and contriving fresh apparatus to facilitate its submersion. Eventually the Telegraph Construction and Maintenance Company, an union of the Gutta Percha Company with the celebrated firm of Glass and Elliott, constructed an entirely new cable, which was not only costlier, but thicker and stronger than the preceding one. The conductor, three hundred pounds per mile, and one-seventh of an inch thick, consisted of seven No. 18 copper wires, each one-twentieth of an inch in thickness. The core or heart of the cable, says a writer in "Chambers's Encyclopædia," was formed of four layers of gutta percha alternating with four of Chatterton's compound (a solution of gutta percha in Stockholm tar); the wire and conductor being seven hundred pounds per mile, and nine-twentieths of an inch thick. Outside this was a coating of hemp or jute yarn, saturated with a preservative com-

position; while the sheath consisted of ten iron wires, each previously covered with five tarred Manilla yarns. The whole cable was an inch and one eighth thick, weighed thirty-five and three-quarter hundredweights per mile, and was strong enough to endure a breaking strain of seven tons and three-quarters. During the various processes of manufacture, the electrical quality of the cable was tested to an unusual extent. The portions of finished core were tested by immersion in water at various temperatures; next submitted to a pressure of six hundred pounds to the square inch, to imitate the ocean pressure at so great depth; then the conducting power of the copper wire was tested by a galvanometer; and various experiments were also made on the insulating property of the gutta percha. The various pieces having been thus severely put to the proof, they were spliced end to end, and the joints or splicings tested. In a word, nothing was left undone that could insure the success or guarantee the stability of the new cable.

When completed, the cable measured two thousand three hundred miles, and weighed upwards of four thousand tons. It was felt that such a burden could only be intrusted to Brunel's "big ship," the *Great Eastern.* For this purpose three huge iron tanks were built, in the fore, middle, and aft holds of the vessel, each from fifty to sixty feet in diameter, and each twenty and a half feet in depth;

and in these the cable was deposited in three vast coils.

On the 23rd of July 1865, the *Great Eastern* left Valentia, the submarine cable being joined end to end to a more massive shore cable, which was hauled up the cliff at Foilhummerum Bay, to a telegraph-house at the top. The electric condition of the cable was continually tested during the ship's voyage across the Atlantic; and more than once its efficiency was disturbed by fragments of wire piercing the gutta percha and destroying the insulation. At length on August 2nd, the cable snapped by overstraining, and the end sank to the bottom in two thousand fathoms water, at a distance of one thousand and sixty-four miles from the Irish coast. Attempts were made to recover it by dredging. A five-armed grapnel, suspended to the end of a stout iron-wire rope five miles long, was flung overboard; and when it reached the bottom, the *Great Eastern* steamed to and fro in the direction where the lost cable was supposed to be lying; but failure followed upon failure, and the cable was never once hooked. There remained nothing to be done but for the *Great Eastern* to return to England with the news of her non-success, and leaving (including the failure of 1857–8) nearly four thousand tons of electric cable at the bottom of the ocean.

The promoters of ocean telegraphy, however, were determined to be resolute to the end. A new Com-

pany was formed, new capital was raised, and a third cable manufactured, differing in some respects from the former. The outside jacket was made of hemp instead of jute; the iron wires of the sheath were galvanized, and the Manilla hemp which covered them was not tarred. Chiefly through the absence of the tar, the weight of the cable was diminished five hundred pounds per mile; while its strength or breaking strain was increased. A sufficient quantity of this improved cable was made to cross the Atlantic, with all due allowance for slack; and also a sufficient quantity of the 1865 cable to remedy the disaster of that year.

On July 13th, 1866, the *Great Eastern* once more set forth on her interesting voyage, accompanied by the steamers *Terrible*, *Medway*, and *Albany*, to assist in the submersion of the cable, and to act as auxiliaries whenever needed. The line of route chosen lay about midway between those of the 1858 and 1865 cables, but at no great distance from either. The *Great Eastern* exchanged telegrams almost continuously with Valentia as she steamed towards the American continent; and great were the congratulations when she safely arrived in the harbour of Heart's Content, Newfoundland, on the 27th.

Operations were next commenced to recover the end of the 1865 cable, and complete its submergence. The *Albany*, *Medway*, and *Terrible* were despatched

on the 1st of August, to the point where, "deep down beneath the darkling waves," the cable was supposed to be lying, and on the 9th or 10th they were joined by the *Great Eastern*, when grappling was commenced, and carried on through the remainder of the month. The cable was repeatedly caught, and raised to a greater or less height from the ocean bed; but something or other snapped or slipped every time, and down went the cable again. At last, after much trial of patience, the end of the cable was safely fished up on September 1st; and electric messages were at once sent through to Valentia, just as well as if the cable had not had twelve months' soaking in the Atlantic. An additional length having been spliced to it, the laying recommenced; and on the 8th the squadron entered Heart's Content, having thus succeeded in laying a second line of cable from Ireland to America.

The two cables, the old and the new, continued to work very smoothly during the winter of 1866 and 1867; but in May 1867, the new cable was damaged by an iceberg, which drifted across it at a distance of about three miles from the Newfoundland shore. The injury was soon repaired; but again, in July 1867, the same cable broke at about fifty miles from Newfoundland.

The earlier cable continued to work for several years, but both cables gave way towards the close of the autumn of 1870. No special inconvenience was

felt, however, as two years ago a French line of cable was laid down between Europe and America; the *Great Eastern* being again employed, and the operations being conducted under the superintendence of English electricians. The two British cables will probably be repaired in the spring of the present year (1871).

Submarine cables have multiplied recently, and almost every ocean flows over the mysterious wires which flash intelligence beneath the rolling waters from point to point of the civilized world. By a telegraph-cable, which is partly submarine, the India Office in Westminster is united with the Governor-General and his Council at Calcutta. There is also communication between Singapore and Australia, and the network of ocean telegraphy is being so rapidly extended that, before long, the British Government in the metropolis will be enabled to convey its instructions in a few hours to the administrative authorities in every British colony. And thus the words which the poet puts into the mouth of "Puck" will be nearly realized in a sense the poet never dreamed of—"I'll put a girdle round about the world in forty minutes."

The Silk Manufacture.

I.—JOHN LOMBE.
II.—WILLIAM LEE.
III.—JOSEPH MARIE JACQUARD.

The Silk Manufacture.

I.—JOHN LOMBE.

In the reign of the Emperor Justinian, a couple of Persian monks, on a religious mission to China, brought away with them a quantity of silkworms' eggs concealed in a piece of hollow cane, which they carried to Constantinople. There they hatched the eggs, reared the worms, and spun the silk,—for the first time introducing that manufacture into Europe, and destroying the close monopoly which China had hitherto enjoyed. From Constantinople the knowledge and the practice of the art gradually extended to Greece, thence to Italy, and next to Spain. Each country, as in turn it gained possession of the secret, strove to preserve it with jealous care; but to little purpose. A secret that so many thousands already shared in common, could not long remain so, although its passage to other countries might be for a time deferred. France and England were behind most of the other states of Europe in obtaining a knowledge of the "craft and mystery." The manufacture of silk did not take root in France till the reign of Francis I.; and was hardly known in England till the persecutions of the Duke of Parma in 1585 drove a great number of the manufacturers of

Antwerp to seek refuge in our land. James I. was very anxious to promote the breed of silkworms, and the production of silken fabrics. During his reign a great many mulberry-trees were planted in various parts of the country—among others, that celebrated one in Shakspeare's garden at Stratford-on-Avon—and an attempt was made to rear the worm in our country, which, however, the ungenial climate frustrated. Silk-throwsters, dyers, and weavers were brought over from the Continent; and the manufacture made such progress that, by 1629, the silk-throwsters of London were incorporated, and thirty years after employed no fewer than 40,000 hands. The emigration from France consequent on the revocation of the Edict of Nantes (1685) added not only to the numbers engaged in the trade, but to the taste, skill, and enterprise with which it was conducted. It is not easy to estimate how deeply France wounded herself by the iniquitous persecution of the Protestants, or how largely the emigrants repaid by their industry the shelter which Britain afforded them.

Although the manufacture had now become fairly naturalized in England, it was restricted by our ignorance of the first process to which the silk was subjected. Up till 1718, the whole of the silk used in England, for whatever purpose, was imported "thrown," that is, formed into threads of various kinds and twists. A young Englishman named

John Lombe, impressed with the idea that our dependence on other countries for a supply of thrown silk prevented us from reaping the full benefit of the manufacture, and from competing with foreign traders, conceived the project of visiting Italy, and discovering the secret of the operation. He accordingly went over to Piedmont in 1715, but found the difficulties greater than he had anticipated. He applied for admittance at several factories, but was told that an examination of the machinery was strictly prohibited. Not to be balked, he resolved, as a last resort, to try if he could accomplish by stratagem what he had failed to do openly. Disguising himself in the dress of a common labourer, he bribed a couple of the workmen connected with one of the factories, and with their connivance obtained access in secret to the works. His visits were few and short; but he made the best use of his time. He carefully examined the various parts of the machinery, ascertained the principle of its operation, and made himself completely master of the whole process of throwing. Each night before he went to bed he noted down everything he had seen, and drew sketches of parts of the machinery. This plot, however, was discovered by the Italians. He and his accomplices had to fly for their lives, and not without great difficulty escaped to a ship which conveyed them to England.

Lombe had not forgotten to carry off with him

his note-book, sketches, and a chest full of machinery, and on his return home lost no time in practising the art of "throwing" silk. On a swampy island in the river Derwent, at Derby, he built a magnificent mill, yet standing, called the "Old Silk Mill." Its erection occupied four years, and cost £30,000. It was five storeys in height, and an eighth of a mile in length. The grand machine numbered no fewer than 13,384 wheels. It was said that it could produce 318,504,960 yards of organzine silk thread daily; but the estimate is no doubt exaggerated.

While the mill was building, Lombe, in order to save time and earn money to carry on the works, opened a manufactory in the Town Hall of Derby. His machinery more than fulfilled his expectations, and enabled him to sell thrown silk at much lower prices than were charged by the Italians. A thriving trade was thus established, and England relieved from all dependence on other countries for "thrown" silk.

The Italians conceived a bitter hatred against Lombe for having broken in upon their monopoly and diminished their trade. In revenge, therefore, according to William Hutton, the historian of Derby, they "determined *his* destruction, and hoped that of his works would follow." An Italian woman was despatched to corrupt her two countrymen who assisted Lombe in the management of the works. She obtained employment in the factory, and gained

over one of the Italians to her iniquitous design. They prepared a slow poison, and administered it in small doses to Lombe, who, after lingering three or four years in agony, died at the early age of twenty-nine. The Italian fled; the woman was seized and subjected to a close examination, but no definite proof could be elicited that Lombe had been poisoned. Lombe was buried in great state, as a mark of respect on the part of his townsmen. "He was," says Hutton, "a man of quiet deportment, who had brought a beneficial manufactory into the place, employed the poor, and at advanced wages,—and thus could not fail to meet with respect; and his melancholy end excited much sympathy."

II.—WILLIAM LEE.

In the Stocking Weavers' Hall, in Redcross Street, London, there used to hang a picture, representing a man in collegiate costume in the act of pointing to an iron stocking-frame, and addressing a woman busily knitting with needles by hand. Underneath the picture appeared the following inscription: "In the year 1589, the ingenious William Lee, A.M., of St. John's College, Cambridge, devised this profitable art for stockings (but, being despised, went to France), yet of iron to himself, but to us and to others of gold; in memory of whom this is here painted." As to who this William Lee was, and the way in which he came to invent the stocking-

frame, there are conflicting stories, but the one most generally received and best authenticated is as follows :—

William Lee, a native of Woodborough, near Nottingham, was a fellow of one of the Cambridge Colleges. He fell in love with a young country lass, married her, and consequently forfeited his fellowship. A poor scholar, with much learning, but without money or the knowledge of any trade, he found himself in very embarrassed circumstances. Like many another "poor scholar," he might exclaim :—

> "All the arts I have skill in,
> Divine and humane;
> Yet all's not worth a shilling;
> Alas! poor scholar, whither wilt thou go?"

His wife, however, was a very industrious woman, and by her knitting contributed to their joint support. It is said—but the story lacks authentic confirmation—that when Lee was courting her, she always appeared so much more occupied with her knitting than with the soft speeches he was whispering in her ear, that her lover thought of inventing a machine that would "facilitate and forward the operation of knitting," and so leave the object of his love more leisure to converse with him. "Love, indeed," says Beckmann, "is fertile in invention, and gave rise, it is said, to the art of painting; but a machine so complex in its parts, and so wonderful in its effects, would seem to require longer and greater reflection, more judgment, and more time and patience than could be expected

WILLIAM LEE, THE INVENTOR OF THE STOCKING-FRAME.

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of a lover." But afterwards, when Lee, in his painfully enforced idleness, sat many a long hour watching his wife's nimble fingers toiling to support him, his mind again recurred to the idea of a machine that would give rest to her weary fingers. His cogitations resulted in the contrivance of a stocking-frame, which imitated the movements of the fingers in knitting.

Although the invention of this loom gave a great impulse to the manufacture of silk stockings in England, and placed our productions in advance of those of other countries, Lee reaped but little profit from it. He met with neglect both from Queen Elizabeth and James I.; and, not succeeding as a manufacturer on his own account, went to France, where he did very well until after the assassination of Henri IV., when he shared the persecutions of the Protestants, and died in great distress in Paris.

III.—JOSEPH MARIE JACQUARD.

Joseph Marie Jacquard, the inventor of the loom which bears his name, and to whom the extent and prosperity of the silk manufacture of our time is mainly due, was born at Lyons in 1752, of humble parents, both of whom were weavers. His father taught him to ply the shuttle ; but for education of any other sort, he was left to his own devices. He managed to pick up some knowledge of reading and writing for himself: but his favourite occupation

was the construction of little models of houses, towers, articles of furniture, and so on, which he executed with much taste and accuracy. On being apprenticed to a type-founder, he exhibited his aptitude for mechanical contrivances by inventing a number of improved tools for the use of the workmen. On his father's death he set up as a manufacturer of figured fabrics; but although a skilful workman, he was a bad manager, and the end of the undertaking was, that he had to sell his looms to pay his debts. He married, but did not receive the dowry with his wife which he expected, and to support his family had to sell the house his father had left him, —the last remnant of his little heritage. The invention of numerous ingenious machines for weaving, type-founding, &c., proved the activity of his genius, but produced not a farthing for the maintenance of his wife and child. He took service with a lime-maker at Brest, while his wife made and sold straw hats in a little shop at Lyons. He solaced himself for the drudgery of his labours by spending his leisure in the study of machines for figure-weaving. The idea of the beautiful apparatus which he afterwards perfected began to dawn on him, but for the time it was driven out of his mind by the stirring transactions of the time. The whirlwind of the Revolution was sweeping through the land. Jacquard ardently embraced the cause of the people, took part in the gallant defence of Lyons in 1793, fled for his

life on the reduction of the city, and with his son—a lad of sixteen—joined the army of the Rhine. His boy fell by his side on the field of battle, and Jacquard, destitute and broken-hearted, returned to Lyons. His house had been burned down; his wife was nowhere to be heard of. At length he discovered her in a miserable garret, earning a bare subsistence by plaiting straw. For want of other employment he shared her labours, till Lyons began to rise from its ruins, to recover its scattered population, and revive its industry. Jacquard applied himself with renewed energy to the completion of the machine of which he had, before the Revolution, conceived the idea; exhibited it at the National Exposition of the Products of Industry in 1801; and obtained a bronze medal and a ten years' patent.

During the peace of Amiens, Jacquard happened to take up a newspaper in a *cabaret* which he frequented, and his eye fell on a translated extract from an English journal, stating that a prize was offered by a society in London for the construction of a machine for weaving nets. As a mere amusement he turned his thoughts to the subject, contrived a number of models, and at last solved the problem. He made a machine and wove a little net with it. One day he met a friend who had read the paragraph from the English paper. Jacquard drew the net from his pocket saying, "Oh! I've got over the difficulty! see, there is a net I've made." After that

he took no more thought about the matter, and had quite forgotten it, when he was startled by a summons to appear at the Prefectal Palace. The prefect received him very kindly, and expressed his astonishment that his mechanical genius should so long have remained in obscurity. Jacquard could not imagine how the prefect had discovered his mechanical experiments, and began vaguely to dread that he had got into some shocking scrape. He stammered out a sort of apology. The prefect was surprised he should deny his own talent, and said he had been informed that he had invented a machine for weaving nets. Jacquard owned that he had.

"Well, then, you're the right man, after all," said the prefect. "I have orders from the emperor to send the machine to Paris."

"Yes, but you must give me time to make it," replied Jacquard.

In a week or two Jacquard again presented himself at the palace with his machine and a half manufactured net. The prefect was eager to see how it worked.

"Count the number of loops in that net," said Jacquard, "and then strike the bar with your foot."

The prefect did so, and was surprised and delighted to see another loop added to the number.

"Capital!" cried he. "I have his majesty's orders, M. Jacquard, to send you and your machine to Paris."

"To Paris! How can that be? How can I leave my business here?"

"There is no help for it; and not only must you go to Paris, but you must start at once, without an hour's delay."

"If it must be, it must. I will go home and pack up a little bundle, and tell my wife about my journey. I shall be ready to start to-morrow."

"To-morrow won't do; you must go to-day. A carriage is waiting to take you to Paris; and you must not go home. I will send to your house for any things you want, and convey any message to your wife. I will provide you with money for the journey."

There was no help for it, so Jacquard got into the carriage, along with a gendarme who was to take charge of him, and wondered, all the way to Paris, what it all meant. On reaching the capital he was taken before Napoleon, who received him in a very condescending manner. Carnot, who was also present, could not at first comprehend the machine, and turning to the inventor, exclaimed roughly, "What, do you pretend to do what is beyond the power of man? Can you tie a knot in a stretched string?" Jacquard, not at all disconcerted, explained the construction of his machine so simply and clearly, as to convince the incredulous minister that it accomplished what he had hitherto deemed an impossibility.

Jacquard was now employed in the Conservatory of Arts and Manufactures to repair and keep in order

the models and machines. At this time a magnificent shawl was being woven in one of the government works for the Empress Josephine. Very costly and complicated machinery was employed, and nearly £1000 had already been spent on it. It appeared to Jacquard that the shawl might be manufactured in a much simpler and less expensive manner. He thought that the principle of a machine of Vaucousin's might be applied to the operation, but found it too complex and slow. He brooded over the subject, made a great many experiments, and at last succeeded in contriving an improved apparatus.

He returned to Lyons to superintend the introduction of his machine for figure-weaving and the manufacture of nets. The former invention was purchased for the use of the people, and was brought into use very slowly. The weavers of Lyons denounced Jacquard as the enemy of the people, who was striving to destroy their trade, and starve themselves and families, and used every effort to prevent the introduction of his machine. They wilfully spoiled their work in order to bring the new process into discredit. The machine was ordered to be destroyed in one of the public squares. It was broken to pieces,—the iron-work was sold for old metal, and the wood-work for faggots. Jacquard himself had on one occasion to be rescued from the hands of a mob who were going to throw him into the Rhone.

Before Jacquard's death in 1835, his apparatus had not only made its way into every manufactory in France, but was used in England, Switzerland, Germany, Italy, and America. Even the Chinese condescended to avail themselves of this invention of a "barbarian."

Jacquard's apparatus is, strictly speaking, not a loom, but an appendage to one. It is intended to elevate or depress, by bars, the warp threads for the reception of the shuttle, the patterns being regulated by means of bands of punched cards acting on needles with loops and eyes. At first applied to silk weaving only, the use of this machine has since been extended to the bobbin-net, carpets, and other fancy manufactures. By its agency the richest and most complex designs, which could formerly be achieved only by the most skilful labourers, with a painful degree of labour, and at an exorbitant cost, are now produced with facility by the most ordinary workmen, and at the most moderate price.

Of late years the silk manufacture has greatly improved, both in character and extent. The products of British looms exhibited at the Great Exhibition of 1862 vied with those of the Continent. Every year upwards of £2,300,000 worth of silk is brought to England; and the silk manufacture engages some £55,000,000 of capital, and employs eleven to twelve hundred thousand of our population.

The Potter's Art.

I.—LUCA DELLA ROBBIA.
II.—BERNARD PALISSY.
III.—JOSIAH WEDGWOOD.

The Potter's Art.

I.—LUCA DELLA ROBBIA.

THERE can be little doubt as to the antiquity of the pottery manufacture. It probably had its origin in that of bricks, which at a very early date men made for purposes of construction; but it is not impossible that he had previously contrived to fabricate the commoner articles of domestic economy, such as pans and dishes, of sun-dried clay.

Bricks, as everybody knows, are fashioned out of a coarse clay, such as we meet with in very numerous localities. After mixing up with water a kind of paste out of these clayey earths, the moulder works up the paste into the shape of bricks, and they are then exposed to the heat of the kiln. Sometimes it was thought sufficient to dry these bricks in the rays of a burning sun; but, so dried, their solidity is very inconsiderable. Baked bricks owe their redness of colour to the oxide of iron which they contain. They are either moulded with the hand or cast in rectangular frames of wood, dusted with sand. To bake them, they are piled up in huge stacks, in which intervals are left for storing and kindling the fuel. They are also baked in kilns.

The commoner pottery wares are manufactured

with the coarse impure clays, which are allowed to rot in trenches for several years to render them more plastic. Flower-pots, sugar-pans, vases, and other and more graceful articles, are moulded on the potter's wheel.

Now, this potter's wheel is one of the most ancient instruments of human industry, one of the earliest inventions by which man utilized and economized his labour. It consists of a large disc of wood, to which a rotatory motion is given by the workman's foot. A second and smaller disc, on which is placed the paste for working, is fixed upon the upper extremity of the vertical axis to which the larger and inferior disc is attached. Seated on his bench, the workman places in the centre of the disc a certain quantity of soft moist clay, and turning the wheel with his foot, moulds the said paste with both hands, until it assumes the desired shape. You can imagine no prettier spectacle than that of a skilful potter causing the clay, under his nimble fingers, to assume the most varied forms. It seems as if by miracle the vase was created suddenly, and the rude clay sprang into a life and beauty of its own.

The Campanian potteries, improperly but commonly called the Etruscan, and the ancient Greek wares, belong to the class of soft and lustrous potteries which are no longer manufactured. The Etruscan vases are the most remarkable specimens of the ancient potter's art; pure, simple, and elegant

in form, they cannot be surpassed by any efforts of the modern potter. The paste of which they are made is very fine and homogeneous, coated with a peculiar glassy lustre, which is thin but tenacious, red or black, and formed of silica rendered fusible by an alkali. They were baked at a low temperature. In this ware, which was in vogue between 500 and 320 B.C., the Aretine and Roman pottery originated. The former was manufactured at Arezzo or Arretium.

The knowledge of glazes, which was acquired by the Egyptians and Assyrians, seems to have been handed down to the Persians, Moors, and Arabs. Fayences, and enamelled bricks and plaques, were commonly used among them in the twelfth century, and among the Hindus in the fourteenth. The celebrated glazed tiles, or *azulejos*, which contribute so much to the beauty of the Alhambra, were introduced into Spain by the Moors about 711 A.D. In Italy, it is supposed, they were made known as early as the conquest of Majorca by the Pisans, in 1115 A.D. But Brongniart places their introduction three centuries later, or in 1415, and says this peculiar kind of ware was called *Majolica*, from Majorica or Majorca. This, however, seems to have been the Italian enamelled fayence, which was used for subjects in relief by the celebrated Florentine sculptor, Luca della Robbia.

Robbia had been bred to the trade of a goldsmith

—in those days a trade of great distinction and opulence—but his artistic tastes could not be controlled, and he abandoned it to become a sculptor. A man of a singularly enthusiastic and ardent nature, he applied himself arduously to his new work. He worked all day with his chisel, and sat up, even through the night, to study. "Often," says Vasari, "when his feet were frozen with cold in the night time, he kept them in a basket of shavings to warm them, that he might not be compelled to discontinue his drawings." Such devotion could hardly fail to secure success. Luca was recognised as one of the first sculptors of the day, and executed a number of great works in bronze and marble. On the conclusion of some important commissions, he was struck with the disproportion between the payment he received and the time and labour he had expended; and, abandoning marble and bronze, resolved to work in clay. Before he could do that, however, it was necessary to discover some means of rendering durable the works which he executed in that material. Applying himself to the task with characteristic zeal and perseverance, he at length succeeded in discovering a mode of protecting such productions from the injuries of time, by means of a glaze or enamel, which conferred not only an almost eternal durability, but additional beauty on his works in terra cotta. At first this enamel was of a pure white, but he afterwards added the further invention of colouring it. The fame of these produc-

tions spread over Europe, and Luca found abundant and profitable employment during the rest of his days, the work being carried on, after his death, by brothers and descendants.

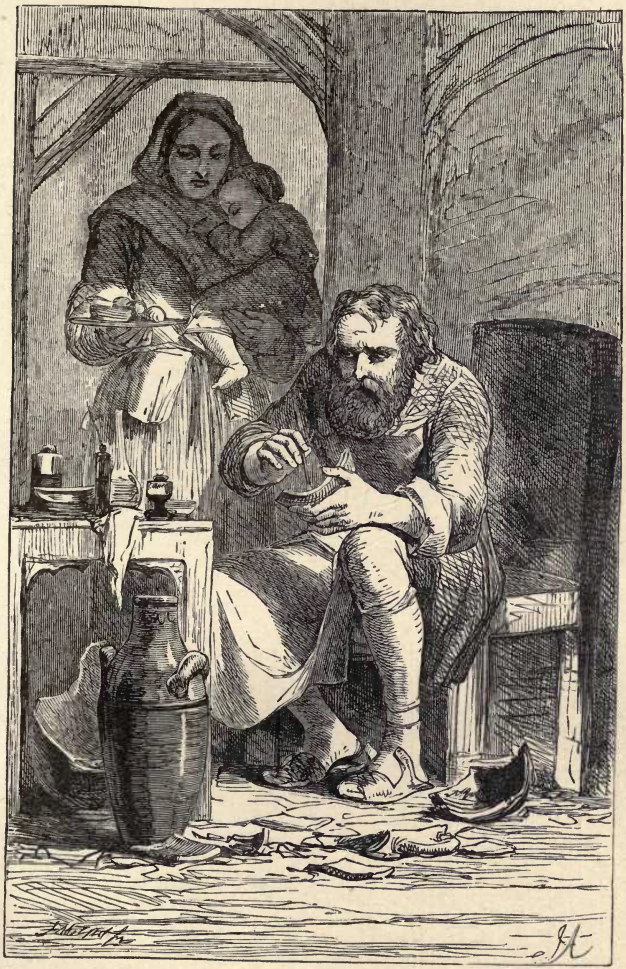
II.—BERNARD PALISSY.

The next great master in the art was Bernard Palissy,—a man distinguished not only for his artistic genius, but for his philosophical attainments, his noble, manly character, and zealous piety. Born of poor parents about the beginning of the sixteenth century, Bernard Palissy was taken as apprentice by a land-surveyor, who had been much struck with the boy's quickness and ingenuity. Land-surveying, of course, involved some knowledge of drawing; and thus a taste for painting was developed. From drawing lines and diagrams he went on to copy from the great masters. As this new talent became known he obtained employment in painting designs on glass. He received commissions in various parts of the country, and in his travels employed his mind in the study of natural objects. He examined the character of the soils and minerals upon his route, and the better to grapple with the subject, devoted his attention to chemistry. At length he settled and married at Staines, and for a time lived thriftily as a painter.

One day he was shown an elegant cup of Italian manufacture, beautifully enamelled. The art of

enamelling was then entirely unknown in France, and Palissy was at once seized with the idea, that if he could but discover the secret it would enable him to place his wife and family in greater comfort. "So, therefore," he writes, "regardless of the fact that I had no knowledge of clays, I began to seek for these enamels as a man gropes in the dark. I reflected that God had gifted me with some knowledge of drawing, and I took courage in my heart, and besought him to give me wisdom and skill."

He lost no time in commencing his experiments. He bought a quantity of earthen pots, broke them into fragments, and covering them with various chemical compounds, baked them in a little furnace of his own construction, in the hope of discovering the white enamel, which he had been told was the key to all the rest. Again and again he varied the ingredients of the compositions, the proportions in which they were mixed, the quality of the clay on which they were spread, the heat of the furnace to which they were subjected; but the white enamel was still as great a mystery as ever. Instead of discouraging, each new defeat seemed to confirm his hope of ultimate success and to increase his perseverance. Painting and surveying he no longer practised, except when sheer necessity compelled him to resort to them to provide bread for his family. The discovery of the enamel had become the great mission of his life, and to that all other occupations must be



PALISSY THE POTTER.

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sacrificed. "Thus having blundered several times at great expense and through much trouble, with sorrows and sighs, I was every day pounding and grinding new materials and constructing new furnaces, which cost much money, and consumed my wood and my time." Two years had passed now in fruitless effort. Food was becoming scarce in the little household, his wife worn and shrewish, the children thin and sickly. But then came the thought to cheer him,—when the enamel was found his fortune would be made, there would then be an end to all his privations, anxieties, and domestic unhappiness, Lisette would live at ease, and his children lack no comfort. No, the work must not be given up yet. His own furnace was clumsy and imperfect,—perhaps his compositions would turn out better in a regular kiln. So more pots were bought and broken into fragments, which, covered with chemical preparations, were fired at a pottery in the neighbourhood. Batch after batch was prepared and despatched to the kiln, but all proved disheartening failures. Still with "great cost, loss of time, confusion, and sorrow," he persevered, the wife growing more shrewish, the children more pinched and haggard. By good luck at this time came the royal commissioners to establish the gabelle or tax in the district of Saintonge, and Palissy was employed to survey the salt marshes. It was a very profitable job, and Palissy's affairs began to look more flourishing. But the work was

no sooner concluded, than the "will o' the wisp," as his wife and neighbours held it, was dancing again before his eyes, and he was back, with redoubled energy, to his favourite occupation, "diving into the secret of enamels."

Two years of unremitting, anxious toil, of grinding and mixing, of innumerable visits to the kiln, sanguine of success, with ever new prèparations; of invariable journeys home again, sad and weary, for the moment utterly discouraged; of domestic bickerings; of mockery and censuré among neighbours, and still the enamel was a mystery,—still Palissy, seemingly as far from the end as ever, was eager to prosecute the search. He appeared to have an inward conviction that he would succeed; but meanwhile the remonstrances of his wife, the pale, thin faces of his bairns, warned him he must desist, and resume the employments that at least brought food and clothing. There should be one more trial on a grand scale,—if that failed, then there should be an end of his experiments. "God willed," he says, "that when I had begun to lose my courage, and was gone for the last time to a glass-furnace, having a man with me carrying more than three hundred pieces, there was one among those pieces which was melted within four hours after it had been placed in the furnace, which trial turned out white and polished, in a way that caused me such joy as made me think I was become a new creature." He rushed home, burst

into his wife's chamber, shouting, "I have found it!"

From that moment he was more enthusiastic than ever in his search. He had discovered the white enamel. The next thing to be done was to apply it. He must now work at home and in secret. He set about moulding vessels of clay after designs of his own, and baked them in a furnace which he had built in imitation of the one at the pottery. The grinding and compounding of the ingredients of the enamel cost him the labour, day and night, of another month. Then all was ready for the final process.

The vessels, coated with the precious mixture, are ranged in the furnace, the fire is lit and blazes fiercely. To stint the supply of fuel would be to cheat himself of a fortune for the sake of a few pence, so he does not spare wood. All that day he diligently feeds the fire, nor lets it slacken through the night. The excitement will not let him sleep even if he would. The prize he has striven for through these weary years, for which he has borne mockery and privation, is now all but within his grasp; in another hour or two he will have possessed it.

The grey dawn comes, but still the enamel melts not. His boy brings him a portion of the scanty family meal. There shall soon be an end to that miserable fare! More faggots are cast on the fire. The night falls, and the sun rises on the third day

of his tending and watching at the furnace door, but still the powder shows no signs of melting. Pale, haggard, sick at heart with anxiety and dread, worn with watching, parched and fevered with the heat of the fire, through another, and yet another and another day and night, through six days and six nights in all, Bernard Palissy watches by the glaring furnace, feeds it continually with wood, and still the enamel is unmelted. "Seeing it was not possible to make the said enamel melt, I was like a man in desperation; and although quite stupified with labour, I counselled to myself that in my mixture there might be some fault. Therefore I began once more to pound and grind more materials, all the time without letting my furnace cool. In this way I had double labour, to pound, grind, and maintain the fire. I was also forced to go again and purchase pots in order to prove the said compound, seeing that I had lost all the vessels which I had made myself. And having covered the new pieces with the said enamel, I put them into the furnace, keeping the fire still at its height."

By this time it was no easy matter to "keep the fire at its height." His stock of fuel was exhausted; he had no money to buy any more, and yet fuel must be had. On the very eve of success—alas! an eve that so seldom has a dawn—it would never do to lose it all for want of wood, not while wood of any kind was procurable. He rushed into the garden,

tore up the palings, the trellis work that supported the vines, gathered every scrap of wood he could find, and cast them on the fire. But soon again the deep red glow of the furnace began to fade, and still it had not done its work. Suddenly a crashing noise was heard; his wife, the children clinging to her gown, rushed in. Palissy had seized the chairs and table, had torn the door from its hinges, wrenched the window frames from their sockets, and broken them in pieces to serve as fuel for the all-devouring fire. Now he was busy breaking up the very flooring of the house. And all in vain! The composition would not melt.

"I suffered an anguish that I cannot speak, for I was quite exhausted and dried up by the heat of the furnace. Further to console me, I was the object of mockery; even those from whom solace was due, ran, crying through the town that I was burning my floors. In this way my credit was taken from me, and I was regarded as a madman," if not, as he tells us elsewhere, as one seeking ill-gotten gains, and sold to the evil one for filthy lucre.

He made another effort, engaged a potter to assist him, giving the clothes off his own back to pay him, and afterwards receiving aid from a friendly neighbour, and this time proved that his mixture was of the right kind. But the furnace having been built with mortar which was full of flints, burst with the heat, and the splinters adhered to the pottery. Sooner than

allow such imperfect specimens of his art to go forth to the world, Palissy destroyed them, "although some would have bought them at a mean price."

Better days, however, were at hand for himself and family. His next efforts were successful. An introduction to the Duke of Montmorency procured him the patronage of that nobleman, as well as of the king. He now found profitable employment for himself and food for his family. "During the space of fifteen or sixteen years in all," he said afterwards, "I have blundered on at my business. When I had learned to guard against one danger, there came another on which I had not reckoned. All this caused me such labour and heaviness of spirit, that before I could render my enamels fusible at the same degrees of heat, I verily thought I should be at the door of my sepulchre. . . . . But I have found nothing better than to observe the counsel of God, his edicts, statutes, and ordinances; and in regard to his will, I have seen that he has commanded his followers to eat bread by the labour of their bodies, and to multiply their talents which he has committed to them."

When the Reformation came, Palissy was an earnest reformer, on Sunday mornings assembling a number of simple, unlearned men for religious worship, and exhorting them to good works. Court favour exempted him from edicts against Protestants, but could not shield him from popular prejudice.

His workshops at Saintes were destroyed; and to save his life and preserve the art he had invented, the king called him to Paris as a servant of his own, Thus he escaped the massacre of St. Bartholomew. Besides being a skilful potter, Palissy was a naturalist of no little eminence. "I have had no other book than heaven and earth, which are open to all," he used to say; but he read the wondrous volume well, while others knew it chiefly at second-hand, and hence his superiority to most of the naturalists of the day. He was in the habit of lecturing to the learned men of the capital on natural history and chemistry. When more than eighty years of age he was accused of heresy, and shut up in the Bastille. The king, visiting him in prison, said, "My good man, if you do not renounce your views upon religious matters, I shall be constrained to leave you in the hands of my enemies." "Sire," replied Palissy, "those who constrain you, a king, can never have power over me, because I know how to die." Palissy died in prison, aged and exhausted, in 1590, at the age of eighty.

Before his death his wares had become famous, and were greatly prized. The enamel, which he went through so much toil and suffering to discover, was the foundation of a flourishing national manufacture.

III.—JOSIAH WEDGWOOD.

Josiah Wedgwood, whose name in connection with pottery-ware has become a household word amongst us, was the younger son of a potter at Burslem, in Staffordshire, who had also a little patch of ground which he farmed. When Josiah was only eleven years old, his father died, and he was thus left dependent upon his elder brother, who employed him as a "thrower" at his own wheel. An attack of small-pox, in its most malignant form, soon after endangered his life, and he survived only by the sacrifice of his left leg, in which the dregs of the disease had settled, and which had to be cut off. Weak and disabled, he was now thrown upon the world to seek his own fortune. At first it was very uphill work with him, and he found it no easy matter to provide even the most frugal fare. He was gifted, however, with a very fine taste in devising patterns for articles of earthenware, and found ready custom for plates, knife-handles, and jugs of fanciful shape. He worked away industriously himself, and was able by degrees to employ assistance and enlarge his establishment. The pottery manufactures of this country were then in a very primitive condition Only the coarsest sort of articles were made, and any attempt to give elegance to the designs was very rare indeed. All the more ornamental and finer class of goods came from the Continent. Wedgwood saw no reason why

we should not emulate foreigners in the beauty of the forms into which the clay was thrown, and made a point of sending out of his own shop articles of as elegant a shape as possible. This feature in his productions was not overlooked by customers, and he found a growing demand for them. The coarseness of the material was, however, a great drawback to the extension of the trade in native pottery; and it seemed almost like throwing good designs away to apply them to such rude wares. Wedgwood saw clearly that if earthenware was ever to become a profitable English manufacture, something must be done to improve the quality of the clay. He brooded over the subject, tested all the different sorts of earth in the district, and at length discovered one, containing silica, which, black in colour before it went into the oven, came out of it a pure and beautiful white. This fact ascertained, he was not long in turning it to practical account, by mixing flint powder with the red earth of the potteries, and thus obtaining a material which became white when exposed to the heat of a furnace. The next step was to cover this material with a transparent glaze; and he could then turn out earthenware as pure in quality as that from the Continent. This was the foundation not only of his own fortune, but of a manufacture which has since provided profitable employment for thousands of his countrymen, besides placing within the reach of even the humblest

of them good serviceable earthenware for household use.

The success of his white stoneware was such, that he was able to quit the little thatched house he had formerly occupied, and open shop in larger and more imposing premises. He increased the number of his hands, and drove an extensive and growing trade. He was not content to halt after the discovery of the white stoneware. On the contrary, the success he had already attained only impelled him to further efforts to improve the trade he had taken up, and which now became quite a passion with him. When he devoted himself to any particular effort in connection with it, his first thought was always how to turn out the very best article that could be made—his last thought was whether it would pay him or not. He stuck up for the honour of old England, and maintained that whatever enterprise could be achieved, that English skill and enterprise was competent to do. Although he had never had any education himself worth speaking of, his natural shrewdness and keen faculty of observation supplied his deficiencies in that respect; and when he applied himself, as he now did, to the study of chemistry, with a view to the improvement of the pottery art, he made rapid and substantial progress, and passed muster creditably even in the company of men of science and learning. He contributed many valuable communications to the Royal Society, and invented a ther-

mometer for measuring the higher degrees of heat employed in the various arts of pottery.

Again his premises proved too confined for his expanding trade, and he removed to a larger establishment, and there perfected that cream-coloured ware with which Queen Charlotte was so delighted, that she ordered a whole service of it, and commanding that it should be called after her—the Queen's Ware, and that its inventor should receive the title of the "Royal Potter."

A royal potter Wedgwood truly was; the very king of earthenware manufactures, resolute in his determination to attain the highest degree of perfection in his productions, indefatigable in his labours, and unstinting in his outlay to secure that end. He invented altogether seven or eight different kinds of ware; and succeeded in combining the greatest delicacy and purity of material, and utmost elegance of design, with strength, durability, and cheapness. The effect of the improvements he successively introduced into the manufacture of earthenware is thus described by a foreign writer about this period: "Its excellent workmanship, its solidity, the advantage which it possesses of sustaining the action of fire, its fine glaze, impenetrable to acids, the beauty and convenience of its form, and the cheapness of its price, have given rise to a commerce so active and so universal, that in travelling from Paris to Petersburg, from Amsterdam to the furthest port of Sweden,

and from Dunkirk to the extremity of the south of France, one is served at every inn with Wedgwood ware. Spain, Portugal, and Italy are supplied with it, and vessels are loaded with it for the East Indies, the West Indies, and the continent of America." Wedgwood himself, when examined before a committee of the House of Commons in 1785, some thirty years after he had begun his operations, stated that from providing only casual employment to a small number of inefficient and badly remunerated workmen, the manufacture had increased to an extent that gave direct employment to about twenty thousand persons, without taking into account the increased numbers who earned a livelihood by digging coals for the use of the potteries, by carrying the productions from one quarter to another, and in many other ways.

Wedgwood did not confine himself to the manufacture of useful articles, though such, of course, formed the bulk of his trade, but published beautiful imitations of Egyptian, Greek, and Etruscan vases, copies of cameos, medallions, tablets, and so on. Valuable sets of old porcelain were frequently intrusted to him for imitation, in which he succeeded so well that it was difficult to tell the original from the counterfeit, except sometimes from the superior excellence and beauty of the latter. When the celebrated Barberini Vase was for sale, Wedgwood, bent upon making copies of it, made heavy bids against the

Duchess of Portland for it; and was only induced to desist by the promise, that he should have the loan of it in order that he might copy it. Accordingly, the duchess had the vase knocked down to her at eighteen hundred guineas, and Wedgwood made fifty copies of it, which he sold at fifty guineas each, and was thus considerably out of pocket by the transaction. He did it, however, not for the sake of profit, but to show what an English pottery could accomplish.

Besides copying from antique objects, Wedgwood tried to rival them in the taste and elegance of original productions. He found out Flaxman when he was an unknown student, and employed him, upon very liberal terms, to design for him; and thus the articles of earthenware which he manufactured proved of the greatest value in the art education of the people. We owe not a little of the improved taste and popular appreciation and enjoyment of the fine arts in our own day to the generous enterprise of Josiah Wedgwood, and his talented designs.

In order to secure every access from the potteries to the eastern and western coasts of the island, Wedgwood proposed, and, with the aid of others whom he induced to join him, carried out the Grand Trunk Canal between the Trent and the Mersey. He himself constructed a turnpike road ten miles in length through the potteries, and built a village for his work-people, which he called Etruria, and where he established his works. He died there in

1795, at the age of sixty-five, leaving a large fortune and an honoured name, which he had acquired by his own industry, enterprise, and generosity.

A remarkable memorial to the genius and artistic labours of Wedgwood was erected in 1863, and some reference to it should undoubtedly be made in these pages.

It is a twofold memorial: a bronze statue at Stoke-upon-Trent, and a memorial institute, erected close to the birth-place of the Great Potter at Burslem. The foundation-stone was laid on the 26th of October by the Right Hon. W. E. Gladstone, M.P., then Chancellor of the Exchequer, in the presence of a very large and enthusiastic assemblage. The Chancellor delivered a public address, which in eloquent terms did homage to Wedgwood's great mental qualities and his services to his country.

He described as his most signal and characteristic merit, the firmness and fulness of his perception of the true law of what we term industrial art, or, in other words, of the application of the higher art to industry—the law which teaches us to aim first at giving to every object the greatest possible degree of fitness and convenience for its purpose, and next at making it the article of the highest degree of beauty, which compatibly with that fitness and convenience it will bear—which does not substitute the secondary for the primary end, but recognizes as part of the business the study to harmonize the two.

Mr. Gladstone observed, that to have a strong grasp of this principle, and to work it out to its results in the details of a vast and varied manufacture, was a praise high enough for any man, at any time and in any place. But he thought it was higher and more peculiar in the case of Wedgwood than it could be in almost any other case. For that truth of art which he saw so clearly, and which lies at the root of excellence, is one of which England, his country, has not usually had a perception at all corresponding in strength and fulness with her other rare endowments. She has long taken a lead among the European nations for the cheapness of her manufactures, not so for their beauty. And if the day should arrive when she shall be as eminent for purity of taste as she is now for economy of production, the result will probably be due to no other single man in so remarkable a degree as to Josiah Wedgwood.

We conclude with a lively extract from the Chancellor's exhaustive and interesting address :—

"Wedgwood," he says, "in his pursuit of beauty, did not overlook exchangeable value or practical usefulness. The first he could not overlook, for he had to live by his trade : and it was by the profit derived from the extended sale of his humbler productions that he was enabled to bear the risks and charges of his higher works. Commerce did for him

what the King of France did for Sèvres, and the Duke of Cumberland for Chelsea, it found him in funds. And I would venture to say that the lower works of Wedgwood are every whit as much distinguished by the fineness and accuracy of their adaptation to their uses as his higher ones by their successful exhibition of the finest arts. Take, for instance, his common plates, of the value of, I know not how few, but certainly of a very few pence each. They fit one another as closely as cards in a pack. At least, I for one have never seen plates that fit like the plates of Wedgwood, and become one solid mass. Such accuracy of form must, I apprehend, render them much more safe in carriage.....

"Again, take such a jug as he would manufacture for the wash-stand table of a garret. I have seen these made apparently of the commonest material used in the trade. But instead of being built up, like the usual and much more fashionable jugs of modern manufacture, in such a shape that a crane could not easily get his neck to bend into them, and the water can hardly be poured out without risk of spraining the wrist, they are constructed in a simple capacious form, of flowing curves, broad at the top, and so well poised that a slight and easy movement of the hand discharges the water. A round cheese-holder or dish, again, generally presents in its upper part a flat space surrounded by a curved rim; but the cheese-holder of Wedgwood will make itself known

by this—that the flat is so dead a flat, and the curve so marked and bold a curve; thus at once furnishing the eye with a line agreeable and well-defined, and affording the utmost available space for the cheese. I feel persuaded that a Wiltshire cheese, if it could speak, would declare itself more comfortable in a dish of Wedgwood's than in any other dish."

The worthiest successor to Wedgwood whom England has known was the late Herbert Minton, who was scarcely less distinguished than his predecessor for perseverance, patient effort, and artistic sentiment. We owe to him in a great measure the revival of the elegant art of manufacturing encaustic tiles.

The principal varieties of ceramic ware now in use are:—1. Porcelain, which is composed, in England, of sand, calcined bones, china-clay, and potash; and, at Dresden, of kaolin, felspar, and broken biscuit-porcelain; 2. Parian, which is used in a liquid state, and poured into plaster-of-paris moulds; 3. Earthenware, the *Fayence* of the Italians, and the *Delft* of the Dutch, made of various kinds of clay, with a mixture of powdered calcined flint; and, 4. Stoneware, composed of several kinds of plastic clay, mixed with felspar and sand, and occasionally a little lime.

It is estimated that our English potteries not only

supply the demand of the United Kingdom, but export ware to the value of nearly a million and a half annually. The establishments are about 190 in number; employ 75,000 to 80,000 operatives; and export 90,000,000 pieces.

The Miner's Safety Lamp.

SIR HUMPHREY DAVY.

The Miner's Safety Lamp.

SIR HUMPHREY DAVY.

"WHAT'S that? Is the house coming down?" cried Mr. Borlase, the surgeon-apothecary of Penzance, jumping out of his cozy arm-chair, as a tremendous explosion shook the house from top to bottom, making a great jingle among the gallipots in the shop below, and rousing him from a comfortable nap.

"Please, sir," said Betty, the housemaid, putting her head into the room, "here's that boy Davy been a-blowing of hisself up agen. Drat him, he's always up to some trick or other! He'll be the death of all of us some day, that boy will, as sure as my name's Betty."

"Bring him here directly," replied her master, knitting his brow, and screwing his mild countenance into an elaborate imitation of that of a judge he once saw at the assizes, with the black cap on, sentencing some poor wretch to be hanged. "Really, this sort of thing won't do at all."

Only, it must be owned, Mr. Borlase had said that many times before, and put on the terrible judicial look too, and yet "that boy Davy" was at his tricks again as much as ever.

"I'll bring as much as I can find of him, sir," said Betty, gathering up her apron, as if she fully expected to discover the object of her search in a fragmentary condition.

Presently there was heard a shuffling in the passage, and a somewhat ungainly youth, about sixteen years of age, was thrust into the room, with the due complement of legs, arms, and other members, and only somewhat the grimier about the face for the explosion. His fingers were all yellow with acids, and his clothes plentifully variegated with stains from the same compounds. At first sight he looked rather a dull, loutish boy, but his sharp, clear eyes somewhat redeemed his expression on a second glance.

"Here he is, sir," cried Betty triumphantly, as though she really had found him in pieces, and took credit for having put him cleverly together again.

"Well, Humphrey," said Mr. Borlase, "what have you been up to now? You'll never rest, I'm afraid, till you have the house on fire."

"Oh! if you please, sir, I was only experimenting in the garret, and there's no harm done."

"No harm done!" echoed Betty; "and if there isn't it's no fault of yours, you nasty monkey. I declare that blow up gave me such a turn you could ha' knocked me down with a feather, and there's a smell all over the house enough to pison any one."

"That'll do, Betty," said her master, finding the grim judicial countenance rather difficult to keep up,

and anxious to pronounce sentence before it quite wore off. "I'll tell you what it is, young Davy, this sort of thing won't do at all. I must speak to Mr. Tonkine about you; and if I catch you at it again, you'll have to take yourself and your experiments somewhere else. So I warn you. You had much better attend to your work. It was only the other day you gave old Goody Jones a paperful of cayenne instead of cinnamon; and there's Joe Grimsly, the beadle, been here half a dozen times this day for those pills I told you to make up, and they're not ready yet. So just you take yourself off, mind your business, and don't let me have any more nonsense, or it'll be the worse for you."

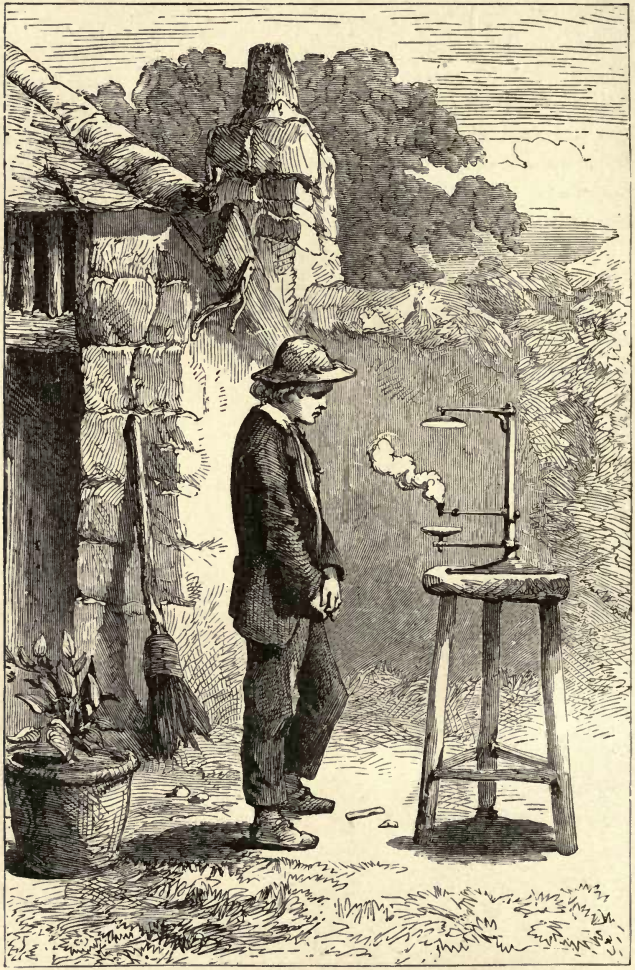
And so the culprit gladly backed out of the room, not a whit abashed by the reprimand, for it was no novelty, to begin his experiments again and again, and one day, by way of compensation for keeping his master's household in constant terror of being blown up, to make his name familiar as a household word, by the invention of a little instrument that would save thousands and thousands from the fearful consequences of coal-pit explosions.

The Mr. Tonkine that his master referred to was the self-constituted protector of the Davy family. Old Davy had been a carver in the town, and dying, left his widow in very distressed circumstances, when this generous friend came forward and took upon himself the charge of the widow and her children.

Young Humphrey, on leaving school, had been placed with Mr. Borlase to be brought up as an apothecary; but he was much fonder of rambling about the country, or experimenting in the garret which he had constituted his laboratory, than compounding drugs behind his master's counter. As a boy he was not particularly smart, although he was distinguished for the facility with which he gleaned the substance of any book that happened to take his fancy, and for an early predilection for poetry. As he grew up, the ardent, inquisitive turn of his mind displayed itself more strongly. He was very fond of spending what leisure time he had in strolling along the rocky coast searching for sea-drift and minerals, or reading some favourite book.

> "There along the beach he wandered, nourishing a youth sublime,
> With the fairy-tales of science, and the long result of time."

In after life he used often to tell how when tired he would sit down on the crags and exercise his fancy in anticipations of future renown, for already the ambition of distinguishing himself in his favourite science had seized him. "I have neither riches, nor power, nor birth," he wrote in his memorandum-book, "to recommend me; yet if I live, I trust I shall not be of less service to mankind and my friends than if I had been born with all these advantages." He read a great deal, and though without much method, managed, in a wonderfully short time, to master the rudiments of natural philosophy



HUMPHREY'S EXPERIMENTS ON THE DIFFUSION OF HEAT.

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and chemistry, to say nothing of considerable acquaintance with botany, anatomy, and geometry; so that though the pestle and mortar might have a quieter time of it than suited his master's notions, Humphrey was busy enough in other ways.

In his walk along the beach, the nature of the air contained in the bladders of sea-weed was a constant subject of speculation with him; and he used to sigh over the limited laboratory at his command, which prevented him from thoroughly investigating the matter. But one day, as good luck would have it, the waves threw up a case of surgical instruments from some wrecked vessel, somewhat rusty and sand clogged, but in Davy's ingenious hands capable of being turned to good account. Out of an old syringe, which was contained in the case, he managed to construct a very tolerable air pump; and with an old shade lamp, and a couple of small metal tubes, he set himself to work to discover the causes of the diffusion of heat. At first sight the want of proper instruments for carrying on his researches might appear rather a hindrance to his progress in the paths of scientific discovery; but, in truth, his subsequent success as an experimentalist has been very properly attributed, in no small degree, to that necessity which is the parent of invention, and which forced him to exercise his skill and ingenuity in making the most of the scanty materials at his command. "Had he,"

says one of his biographers, "in the commencement of his career been furnished with all those appliances which he enjoyed at a later period, it is more than probable that he might never have acquired that wonderful tact of manipulation, that ability of suggesting expedients, and of contriving apparatus, so as to meet and surmount the difficulties which must constantly arise during the progress of the philosopher through the unbeaten track and unexplored regions of science!"

While Davy was thus busily engaged qualifying himself for the distinguished career that awaited him, Gregory Watt, the son of the celebrated James Watt, being in delicate health, came to Penzance for change of air, and lodged with Mrs. Davy. At first he and Humphrey did not get on very well together, for the latter had just been reading some metaphysical works, and was very fond of indulging in crude and flippant speculations on such subjects, which rather displeased the shy invalid. But one day some chance remark of Davy's gave token of his extensive knowledge of natural history and chemistry, and thenceforth a close intimacy sprang up between them, greatly to the lad's advantage, for Watt's scientific knowledge set him in a more systematic groove of study, and encouraged him to concentrate his energies on his favourite pursuit.

Another useful friend Davy also found in Mr. Gilbert, afterwards President of the Royal Society.

Passing along one day, Mr. Gilbert observed a youth making strange contortions of face as he hung over the hutch gate of Borlase's house; and being told by a companion that he was "the son of Davy the carver," and very fond of making chemical experiments, he had a talk with the lad, and discovering his talents, was ever afterwards his staunch friend and patron.

Through his two friends, Mr. Gilbert and Mr. Watt, Davy formed the acquaintance of Dr. Beddoes, who was just setting up at Bristol, under the title of Pneumatic Institution, an establishment for investigating the medical properties of different gases; and who, appreciating his abilities, gave him the superintendence of the new institution.

Although only twenty years of age at this time, Davy was well abreast of the science of the day, and soon applied his vigorous and searching intellect to several successful investigations. His first scientific discovery was the detection of siliceous earth in the outer coating of reeds and grasses. A child was rubbing two pieces of bonnet cane together, and he noticed that a faint light was emitted; and on striking them sharply together, vivid sparks were produced just as if they had been flint and steel. The fact that when the outer skin was peeled off this property was destroyed, showed that it was confined to the skin, and on subjecting it to analysis silex was obtained, and still more in reeds and grasses.

As superintendent of Dr. Beddoe's institution, his attention was, of course, chiefly directed to the subject of gases, and with the enthusiasm of youth, he applied himself ardently to the investigation of their elements and effects, attempting several very dangerous experiments in breathing gases, and more than once nearly sacrificing his life. In the course of these experiments he found out the peculiar properties of nitrous oxide, or, as it has since been popularly called, "laughing gas," which impels any one who inhales it to go through some characteristic action,—a droll fellow to laugh, a dismal one to weep and sigh, a pugnacious man to fight and wrestle, or a musical one to sing.

At twenty-two years of age, such was the reputation he had acquired, that he got the appointment of lecturer at the Royal Institution, which was just then established, and found himself in a little while not only a man of mark in the scientific, but a "lion" in the fashionable world. Natural philosophy and chemistry had begun to attract a good deal of attention at that time; and Davy's enthusiasm, his clear and vivid explanations of the mysteries of science, and the poetry and imagination with which he invested the dry bones of scientific facts, caught the popular taste exactly. His lecture-room became a fashionable lounge, and was crowded with all sorts of distinguished people. The young lecturer became quite the rage, and was petted and feted as the lion

of the day. It was only six years back that he was the druggist's boy in a little country town, alarming and annoying the household with his indefatigable experiments. He could hardly have imagined, as one of his day-dreams at the sea-side, that his fame would be acquired so quickly.

In spite of all the flatteries and attentions which were showered upon him, Davy stuck manfully to his profession; and if his reputation was somewhat artificial and exaggerated at the commencement, he amply earned and consolidated it by his valuable contributions to science during the rest of his career.

The name of Humphrey Davy will always be best known from its association with the ingenious safety lamp which he invented, and which well entitles him to rank as one of the benefactors of mankind. It was in the year 1815 that Davy first turned his attention to this subject. Of frequent occurrence from the very first commencement of coal-mining, the number of accidents from fire-damp had been sadly multiplied by the increase of mining operations consequent on the introduction of the steam engine. The dreadful character of some of the explosions which occurred about this time, the appalling number of lives lost, and the wide-spread desolation in some of the colliery districts which they had occasioned, weighed heavily on the minds of all connected with such matters. Not merely were the feelings of

humanity wounded by the terrible and constant danger to which the intrepid miners were exposed, but it began to be gravely questioned whether the high rate of wage which the collier required to pay him not only for his labour, but for the risk he ran, would admit of the mines being profitably worked. It was felt that some strenuous effort must be made to preserve the miners from their awful foe. Davy was then in the plenitude of his reputation, and a committee of coal-owners besought him to investigate the subject, and if possible provide some preventative against explosions. Davy at once went to the north of England, visited a number of the principal pits, obtained specimens of fire-damp, analyzed them carefully, and having discovered the peculiarities of this element of destruction, after numerous experiments devised the safety-lamp as its antagonist.

The principles upon which this contrivance rests, are the modification of the explosive tendencies of fire-damp (the inflammable gas in mines) when mixed with carbonic acid and nitrogen; and the obstacle presented to the passage of an explosion, if it should occur, through a hole less than the seventh of an inch in diameter; and accordingly, while the small oil lamp in burning itself mixes the surrounding gas with carbonic acid and nitrogen, the cylinder of wire-gauze which surrounds it prevents the escape of any explosion. It is curious that George Stephenson, the

celebrated engineer, about the same time, hit on much the same expedient.

To control a "power that in its tremendous effects seems to emulate the lightning and the earthquake," and to enclose it in a net of the most slender texture, was indeed a grand achievement; and when we consider the many thousand lives which it has been the means of saving from a sudden and cruel death, it must be acknowledged to be one of the noblest triumphs, not only of science, but of humanity, which the world has ever seen. Honours were showered upon Davy, from the miners and coal-owners, from scientific associations, from crowned heads; but all must agree with Playfair in thinking that "it is little that the highest praise, and that even the voice of national gratitude when most strongly expressed, can add to the happiness of one who is conscious of having done such a service to his fellow-men." Davy himself said he "valued it more than anything he ever did." When urged by his friends to take out a patent for the invention, he replied,—"No, I never thought of such a thing. My sole object was to serve the cause of humanity, and if I have succeeded, I am amply rewarded by the gratifying reflection of having done so."

The honours of knighthood and baronetage were successively conferred on Davy as a reward for his scientific labours; and the esteem of his professional brethren was shown in his election to the President-

ship of the Royal Institution, in which, oddly enough, he was succeeded by his old friend Mr. Gilbert, who had first taken him by the hand, and whom he had got ahead of in the race of life.

Davy died at Geneva before he had completed his fifty-first year, no doubt from over-exertion and the unhealthy character of the researches he prosecuted so recklessly. Assiduous as he was in his devotion to his favourite science, he found time also to master several continental languages; to keep himself well acquainted with, and also to contribute to the literature of the day; and to indulge his passion for fly-fishing, at which he was a keen and practised adept.

Eminent as were the talents of Sir Humphrey Davy, and valuable as his discovery of the safety-lamp has proved, it is but fair to own that his credit to the latter has been very openly denied. Two persons of scientific celebrity have been put forward as the real inventors of the safety-lamp—namely, Dr. Reid Clanny of Newcastle, and the great railway-engineer, George Stephenson. Of Clanny's safety-lamp a description appeared in the *Philosophical Transactions* in 1813—that is, ten years before Sir Humphrey made his communication to the Royal Society. However, it was a complicated affair, which required the whole attention of a boy to work it, and was based on the principle of forcing in air through water by the agency of bellows.

Stephenson's was a very different apparatus. In its general principle it resembled Davy's, the chief difference being, that he inserted a glass cylinder inside the wire-gauze cylinder, and inside the top of the glass cylinder a perforated metallic chimney—the supply of air being kept up through a triple circle of small holes in the bottom.

Stephenson's claim has, of course, been disputed by the friends and admirers of Sir Humphrey Davy; but Mr. Smile has conclusively proved that his lamp, the "Geordy," was in use at the Killingworth collieries at the very time that Davy was conducting the experiments which led to his invention. It is not to be inferred, however, that Davy knew aught of what Stephenson had accomplished. It seems to be one of those rare cases in which two minds, working independently, and unknown each to the other, have both arrived simultaneously at the same result.

Penny Postage.

SIR ROWLAND HILL.

Penny Postage.

"He comes, the herald of a noisy world,
News from all nations lumb'ring at his back,—
Houses in ashes, and the fall of stocks;
Births, deaths, and marriages; epistles wet
With tears that trickled down the writer's cheeks
Fast as the periods of his fluent quill;
Or charged with am'rous sighs of absent swains,
Or nymphs responsive." COWPER.

THE growth of the postal system is a sure measure of the progress of industry, commerce, education, and all that goes to make up the sum of civilization; and there is no more striking illustration to be found of the strides which our country has made in that direction since the century began than the introduction of a cheap and rapid delivery of letters, and the craving which it has at once satisfied and augmented. Nothing gives us so forcible an idea of the difference between the Britain of the present day and the Britain of the Stuart or even of the Georgian period, than the contrast between the postal communication of these times and of our own. The itch of writing is now so strong in us, we are so constantly writing or receiving letters, our appetite for them is so ravenous, that we wonder how people got on in the days when the postman was the exclusive messenger of the king, and when even majesty was so badly served that, as one old

postmaster* wrote in self-exculpation of some delay, "when placards are sent (to order the immediate forwarding of some state despatches) the constables many times be fayne to take the horses oute of plowes and cartes, wherein," he gravely adds, "can be no extreme diligence." It was a sure sign that the country was going ahead when Cromwell (1656) found it worth while to establish posts for the people at large, and was able to farm out the post office for £10,000 a year. The profits of that establishment were doubled by the time the Stuarts returned to the throne, and more than doubled again before the close of the seventeenth century. The country has kept on growing out of system after system, like a lad out of his clothes, and at different times has had new ones made to its measure. Brian Tuke's easy plan of borrowing farmers' horses on which to mount his emissaries, gave place to regular relays of post-boys and post-horses; and, in course of time, when the robbery of the mails by sturdy highwaymen had become almost the rule, and their safe conveyance the exception, post-boys were in turn supplanted by a system of stage-coaches, convoyed by an armed guard. This was thought a great advance; and so it was. A pushing, zealous man named Palmer originated the scheme. Amidst many other avocations, he found time to travel on the outside of

* Brian Tuke, master of the post to King Henry VIII.

stage-coaches, for the sake of talking with the coachmen and observing the routes, here, there, and everywhere all over England, and thus matured all the details of his plan from personal experience. "None but an enthusiast," said Sheridan in a rapture of admiration in the House of Commons, "could have conceived, none but an enthusiast could have practically entertained, none but an enthusiast could have carried out such a system."

Still, in spite of the exactitude with which Palmer's scheme was declared to fit the wants of the country, it soon began to be grown out of like the rest. It became too short, too tight, too straitened every way, and impeded the circulation of correspondence,—no unimportant artery of our national system. The cost of postage was too high, the mode of delivery too slow, and the consequence was, that people either repressed their desire to write letters, or sent them through some cheaper and illegitimate channel. Sir Walter Scott knew a man who recollected the mail from London reaching Edinburgh with only a single letter. Of all the tens of thousands of the modern Babylon, only one solitary individual had got anything to say to anybody in the metropolis of the sister kingdom worth paying postage for. "We look back now," writes Miss Martineau, "with a sort of amazed compassion to the old crusading times, when warrior-husbands and their wives, grey-headed parents and their brave sons, parted with the know-

ledge that it must be months or years before they could hear of one another's existence. We wonder how they bore the depth of silence! And we feel the same now about the families of Polar voyagers. But, till a dozen years ago, it did not occur to many of us how like this was the fate of the largest class in our own country. The fact is, there was no full and free epistolary intercourse in the country, except between those who had the command of franks. There were few families in the wide middle class who did not feel the cost of postage a heavy item in their expenditure; and if the young people sent letters home only once a fortnight, the amount at the year's end was a rather serious matter. But it was the vast multitudes of the lower orders who suffered like the crusading families of old, and the geographical discoverers of all times. When once their families parted off from home it was a separation almost like that of death. The hundreds of thousands of apprentices, of shopmen, of governesses, of domestic servants, were cut off from family relations as if seas or deserts lay between them and home. If the shilling for each letter could be saved by the economy of weeks or months at first, the rarity of correspondence went on to increase the rarity; new interests hastened the dying out of old ones; and the ancient domestic affections were but too apt to wither away, till the wish for intercourse was gone. The young girl could not ease her heart

by pouring out her cares and difficulties to her mother before she slept, as she can now, when the penny and the sheet of paper are the only condition of the correspondence. The young lad felt that a letter home was a serious and formal matter, when it must cost his parents more than any indulgence they ever thought of for themselves; and the old fun and light-heartedness were dropped off from such domestic intercourse as there was. The effect upon the morals of this kind of restraint is proved beyond a doubt by the evidence afforded in the army. It was a well-known fact, that in regiments where the commanding officer was kind and courteous about franking letters for the privates, and encouraged them to write as often as they pleased, the soldiers were more sober and manly, more virtuous and domestic in their affections, than where difficulty was made by the indolence or stiffness of the franking officer."

Under the costly postal system, the revenue of the post office did not, as it had hitherto done, and should have continued to do, keep pace with the progress of the country. The appetite for communication between distant friends or men of business was evidently either decaying, or finding vent in an unlawful way. The latter was chiefly the case. There were vast numbers of people separated from each other by long weary miles, too many to permit of visits, who could not resist writing to each other,—the doating parent to the child, the lover to his

mistress, the merchant to his agents, the lawyer to his clients. Those who could not afford postage, were the very class who could not get franks; for the principle was, that those who could best afford postage money should have plenty of franks, which were, of course, quite out of the way of poor, humble folks,—the fat sow had his ear well greased, the lean, starving one had to consume his own fat, like the bear, or go without. The consequence was, that those who were eager to write and could not get letters through the post, found other means of forwarding them to the evasion of the law. There was no limit to the exercise of ingenuity in this direction. Three or four letters were written on one piece of paper, to be cut up and distributed separately by one of the recipients; newspapers were turned into letters by underscoring or pricking with a pin the letters required to form the various words of the communication; some peculiarity in the style of address on the outside was arranged between correspondents, the sight of which was enough to indicate a message, and the letter was then rejected, having served its purpose; and so on, in a hundred other ways, fraudulent means were found of evading the law. Some carriers had a large and profitable business in smuggling letters. In many populous districts the number of letters conveyed by carriers at a penny each in an illegal way far exceeded those sent through the post. In Manchester, for every

letter that went by the postman, six went by the carrier; and in Glasgow the proportion was as one to ten. All this was notorious. The most honourable people saw no great harm in cheating the post to send a word of comfort or encouragement to an absent friend,—it was a vice that leaned to virtue's side. But it was a bad thing for the country that people should be driven to such devices, in obeying a natural and proper impulse. The man who began by smuggling letters, might end by smuggling tobacco or brandy; and the system was morally pernicious. All felt the evil, but remedy seemed impossible. As the urgency for a change grew to a head, the man came to effect it, —a man "of open heart, who could enter into family impulses; a man of philosophical ingenuity, who could devise a remedial scheme; a man of business, who could fortify such a scheme with impregnable accuracy"—that man was Rowland Hill.

When quite a young man, on a pedestrian excursion through the lake district, Rowland Hill, passing a cottage door, observed the postman deliver a letter to a woman, and overheard her, after looking anxiously at the envelope, and then returning it, say she had no money to pay the postage. The man was about to put it back in his wallet and pass on, for it was an every-day thing for him to receive such a reply from the poor countryfolk, when Mr. Hill in his goodness of heart, out of compassion for the woman, stepped forward and paid the shilling, regardless of many

shakes of the head, and hints of remonstrance from her, which he interpreted as merely unwillingness to trespass on a stranger's bounty. As soon as the postman was out of sight she broke the seal, and showed him why she did not want him to pay for the letter. The sheet was a blank, and the envelope had served as a means of communication between her and her correspondent. It appeared that she had arranged with her brother, that as long as all went well with him he should send a blank sheet in that way once a quarter, and thus she had tidings of him without paying the postage.

As he pursued his walk, Mr. Hill could not help meditating on the incident, which had made a deep impression on his mind. He could not blame the poor woman and her brother for the trick they had played upon the post office in order to correspond with each other; and yet he felt there must be something wrong in a system which put it out of their reach, and of others similarly circumstanced, to do so in a lawful manner. Every country post-master had a budget of touching stories of poor folk who were tantalized with the sight of a letter from some dear one, full, perhaps, of kind words and cheering news, or asking sympathy and condolence in misfortune, or transmitting money to help them in their straits; as well as of countless little frauds of the sort described, which they could not always harden themselves to circumvent and punish, so piteously

eager did the poor souls appear to be to get word of their friends. And yet, in spite of all sorts of frauds, to people in humble life letters came like "angels' visits, few and far between."

Mr. Hill asked himself whether there was no means of lessening the cost of postage, whether the government could not afford to charge a lower rate, or manage to get the work done more cheaply? Keeping his ears and eyes open, always on the alert to pick up a fact as regarded the present, or a hint for the future, examining the mode of carriage and delivery, the routes chosen, and the time occupied, Mr. Hill, after a while, arrived at the conviction, that the postage rates might not only be reduced, but that the transmission of letters might be more quickly performed by a remodelling of the system. He ascertained that the cost of mere transit incurred upon a letter sent from London to Edinburgh, a distance of 400 miles, was not more than a thirty-sixth part of a penny, and that, therefore, there was a margin, under the existing charge, of $11\frac{35}{36}$d. for extra expenses and profit. He observed that the twopenny posts of London and other large towns were found to answer very well, although people, being within easy distances of each other, did not need so much as in the country to correspond in writing, and that the carriers, in spite of the illegality of the traffic, had loads of letters to deliver at a penny each, and that penny paid them for their trouble, as well as their risk of detection.

He therefore came to the conclusion, that what was wanted, and what it was quite possible to establish, was a uniform penny postage rate over the whole of the United Kingdom. He calculated that if that were adopted, the number of people then in the habit of writing letters would write a great many more than ever; that others, who had been precluded by the expense from corresponding, would come into the field; and that hundreds of letters forwarded illegally would now pass through the post, so that the number of letters sent by post would be increased fourfold, and the revenue, at first, perhaps a trifle curtailed, would soon mount up again.

The post-office authorities were greatly shocked and disgusted at so audacious and utopian a proposal. But the public were greatly delighted with it, only doubting whether it was not too good news to be true. First by means of an anonymous pamphlet, then by direct and personal application to the government, Mr. Hill endeavoured to get his plans taken into consideration—no easy matter, for circumlocution officials had passed from contemptuous indifference to active hostility, as they gradually discovered how formidable an antagonist in the truth and accuracy of his calculations, the sincerity and earnestness of his purpose, they had to deal with. It was a great national cause Mr. Hill was fighting, and he was not to be put down. The people took his side, Parliament granted an inquiry,

and the result was a report in favour of his scheme. On the 17th of August 1839—why is not the anniversary kept with rejoicings?—penny postage became the law of the land.

During the last weeks of the year a uniform four-penny rate was charged by way of accustoming people to the cheap system, and saving official feelings from the rude shock of a sudden descent from the respectable rate of a shilling, to the vulgar one of a penny. On the 10th January 1840 the penny system came into force. At first Mr. Hill availed himself of a suggestion thrown out some years before by Mr. Charles Knight, that the best way of collecting the penny postage on newspapers would be to have stamped covers; but subsequently stamped envelopes were done away with, and queen's heads introduced. The franking privilege, of course, died with the dear postage.

Upon the adoption of the scheme, Mr. Hill received an appointment in the post office in order to superintend its working; but he had an uneasy berth of it. His plan was adopted only in part,—the postage rate was lowered, while the other compensating and essential features were thrown aside; official jealousy of reform showed itself in various attempts to thwart his efforts, and to fulfil its prediction of failure to the scheme. The consequence was, that the immediate results were not so satisfactory as could have been wished. The increase in

the number of letters was certainly very great. During the last month of the old system the total number of letters passing through the post office was little more than two millions and a half, of which only a fifth were paid letters; while a twelvemonth after the introduction of the new system the total number of letters had risen to nearly six millions per month, of which the unpaid letters formed less than a twelfth part. Very heavy expenses, however, not connected with the new plan, had been incurred; and the consequence was, that the profits of the post office were only a fourth of what they had been. Advantage was taken of this to get Mr. Hill ousted from his post; but, after he had transferred his services for some years to the management of the London and Brighton Railway, the authorities were glad to receive him back again, to place the remodelling of the system in his hands, and to allow him to introduce the other parts of his scheme which had before been neglected. In this work Mr. Hill was busily engaged for a number of years, and most of his plans were gradually carried out with great advantage to the public. In 1846 a public testimonial of £13,360 was presented to Mr. Hill in acknowledgment of his distinguished services to the country; and at a later date he was made a Knight of the Bath.

Cheap postage has now been fairly tried, and must be pronounced a grand success. It has become

part and parcel of our national life, and has been found precious as the gift of a new faculty. We should miss the loss of cheap and rapid correspondence with our friends and acquaintances almost as much as the loss of speech or the loss of sight. The postman has now to find his way to the humblest, poorest districts, where twenty years back his knock was never heard ; and what was once a rare luxury, has now come to be considered a common necessary of life. Instead of only seventy-six millions of letters passing through the post in a year, as in 1838, the number has risen to between seven and eight hundred millions. On the average every individual in England receives twenty-eight letters a-year (in London the individual average is forty-six), in Scotland eighteen, and in Ireland nine.

The gross revenue derived from these sources is over four millions; and some of the railway companies each make more money out of the conveyance of the mails in a year, than the annual revenue of the whole kingdom in the days of William and Mary.

The moral and social effects of the cheap postage are incalculable. It has tended to strengthen and perpetuate domestic ties, to bring the most scattered and distant members of a family under the benign influences of home, and to foster feelings of friendship and sympathy between man and man. Upon the education and intelligence of the people, too, it

has had, concurrently with other causes, a marked effect. Many who looked upon the art of writing as only a temptation to forgery, were induced to take pen in hand and master the science of pot-hooks and hangers, for the sake of corresponding with their friends, and of being able to read the letters they received. In 1839 a third of the men and half of the women who were married, according to the registrar's returns, could not sign their own names; in 1857 that was the case with only a seventh of the men, and a fifth of the women; and not a little of this advanced education may be attributed to the impulse given by the introduction of cheap postage.

Nor have the advantages derived from the post office by the great body of the public ended here. It has shown itself the most progressive department of the government, and has undertaken many benevolent branches of work which were never contemplated by Sir Rowland Hill. Thus it carries on an extensive savings-bank system, worked out by Mr. Frank Ives Scudamore, adopted by Mr. Gladstone when Chancellor of the Exchequer, and established by Act of Parliament in 1861. This valuable department, whose operations are now of a very extensive character, keeps a separate account for every depositor, acknowledges the receipt, and, on the requisite notice being furnished, sends out warrants authorizing post-masters to pay such sums as depositors may wish to withdraw. The deposits are

handed over to the Commissioners for the reduction of the National Debt, and repaid to the depositors through the post office. The rate of interest payable to depositors is two and a half per cent. Each depositor has his savings-bank book, which is sent to him yearly for examination, and the increasing interest calculated and allowed.

The post office now acts, too, as a life-insurance society, offering advantages to the operative which no other society can offer, and which the public are beginning to appreciate.

In 1869 the entire telegraphic system of the United Kingdom passed into the hands of the post office, whose administrators have shown themselves anxious to offer increased facilities to the public for the transaction of business. The number of telegraphic stations has been greatly increased, and the rate reduced at which messages are flashed from one part of the island to the other.

Finally, a recent innovation, made entirely in the interest of the public weal, is the introduction of *Halfpenny Post Cards*. On one side of these missives the sender writes the name and address of his correspondent; on the other, the communication intended for him. The card already bears a half-penny stamp impressed, and nothing more remains to be done but to deposit it in the nearest office or pillar-post. We think, then, it may fairly be said that the post office has shown itself anxious to "keep

abreast" with the ever-increasing wants of the commercial classes of Great Britain.

While these pages are passing through the press, the following particulars, apparently issued under official direction, have attracted our attention. We append them here, as they cannot fail to interest the reader:—"It appears that there are in the United Kingdom 6 miles 712 yards of *pneumatic tubes* in connection with the postal telegraphic system (1871). Of these, 4 miles 638 yards exist in London, and 2 miles 74 yards in the provinces—the latter being confined to Liverpool, Manchester, Birmingham, and Glasgow. Of the total length of tubes now existing, only 2 miles 1324 yards existed prior to the transfer of the telegraphs to the post office; so that no less than 3 miles 1148 yards have been laid since that date; or, in other words, the system has been considerably more than doubled in less than a year. The total length of new tubes ordered and in progress exceeds 3 miles, and when these are completed, the system will be nearly 10 miles in length. All of the tubes in the provinces, and all but two of those in London, are worked on Clark's system. The two which form an exception are those between Telegraph Street and St. Martin's-le-Grand, which are worked on Siemens' system. The former are made of lead, with a diameter varying from 1¼ to 2¼ inches—the more frequent size

being 1½ inches. The latter are made of iron, and have a diameter of 3 inches. The idea of iron tubes worked on Siemens' principle is derived, we believe, from Berlin, where the system is entirely of this description; and of the new tubes in progress, that from St. Martin's-le-Grand to Temple Bar will be of this kind. All of the tubes now in existence are worked in both directions by means of alternate pressure and vacuum; the motive power, in the shape of a steam-engine, being stationed at the central office, with which the out-stations have communication by this means. It is interesting to note the difference of time occupied by the different tubes in London in passing the "carriers" through from one end to the other—the speed being governed by the length and diameter of the tube, and by the circumstance whether it is carried in a straight line, or has to encounter sharp curves and bends on its way. The great advantage of this means of communication, for short distance, over the electric is, that the tubes are not liable to sudden blocks of work as the wires are, and that a dozen or more messages may be sent through, at one blow, if desired. For local telegraphs in great towns the pneumatic system is invaluable, and is certain to be greatly extended under the postal administration.

The Overland Route.

LIEUTENANT WAGHORN.

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WORTHY to stand on a par with, or at lowest, in the very next rank to, the men who originate great inventions, are those whose foresight and energy discover the means of extending their utility; and in shortening the journey between Europe and India, by the establishment of the overland route, Lieutenant Waghorn practically achieved as great a triumph over time and space, as if he had invented a machine for the purpose that would have traversed the old route in the same time.

It was in 1827 that Thomas Waghorn first promulgated the idea of steam communication between our Eastern possessions and the mother country. He was then twenty-seven years of age, and had just returned to Calcutta from rough and arduous service in the Arracan war. When a midshipman of barely seventeen, he had passed the "navigation" examination for lieutenant,—the youngest, it appears, who ever did so; but although, consequently, eligible for that rank, he had never reached it up to this time, in spite of the distinction he had acquired in various actions. His health had been so much shattered by a fever caught in Arracan, that he had to return to England; but he did not leave Calcutta without

communicating his design to the government there, and obtaining a letter of credence from Lord Combermere (then vice-president in council) to the East India Company, recommending him, in consequence of his meritorious conduct in the recent war, "as a fit and proper person to open steam navigation with India, *via* the Cape of Good Hope."

The idea, however, was just then in advance of the time, and all Waghorn's agitation in its favour proved of no avail. In the meantime, the idea of saving the time spent in "doubling the Cape," by means of a route through the Mediterranean, across the Isthmus of Suez, and down the Red Sea, had occurred to him; and in 1829 he procured a commission from the East India Directory to report on the probability of Red Sea navigation, and at the same time to convey certain despatches to Sir John Malcolm, Governor of Bombay.

He got notice of this mission on the 24th October, and was desired to be at Suez by the 8th December, in order to catch the steamer *Enterprise*, and proceed in her to India. He took only four days to make ready for the journey, and on the 28th left London on the top of the *Eagle* stage-coach from Gracechurch Street. Circumstances were anything but propitious all through this expedition of his; and yet he defied and disregarded them all. Bridges broke down at central points, falling avalanches had to be kept clear off, an accident disabled the steamer, and

he had to go some hundred and thirty miles out of his way in consequence. In spite of all that, he dashed through five kingdoms, and reached Trieste in nine days, or little more than half the time occupied by the post-office mails on the same journey. Impatient of delay, he learned that an Austrian brig had left for Alexandria the night before, but the breeze had fallen, and she was still to be caught a glimpse of from the hill-tops. A fresh posting carriage was got out, and off he went in chase of the vessel, hoping to make up to her at Pesano, twenty miles down the Gulf of Venice. The calm still prevailed; and as he went dashing along he could catch sight, now and then, as the carriage passed some open part of the road and disclosed the sea, of the brig creeping lazily along. Every hour he gained on her; instead of a dull, black speck upon the horizon, he began to make out her hull, her sails, and rigging. He urged the post-boys with redoubled vehemence—kept them going at a furious pace. He was within three miles of the vessel—it was crawling, he was flying—another half hour would see him safe on board, and then heigh for India. But stay, surely that was the wind among the trees; could the breeze have risen? It had indeed. A strong northerly wind sprang up; gradually the sails of the brig swelled out before it, and poor Waghorn, with his panting, jaded horses, was left far behind. The chase was hopeless now—so he went back mournfully to Trieste—"exhausted

in body with fatigue, and racked by disappointment after the previous excitement."

The next ship, a Spanish one, was not to sail for three days. That was more than Waghorn could endure; he went to the captain, urged him, bribed him with fifty dollars to make it two days, instead of three, and succeeded. In eight and forty hours he was somewhat consoled for his former discouragement, to find himself at length at sea. In sixteen days he was at Alexandria, and after a rest of only five hours there, hired donkeys and was off to Rosetta. The donkeys were in the conspiracy against him, as well as the wind and the avalanches. The first day they trotted and walked along as brisk as may be, and our indefatigable traveller worked them well. It is well known that the donkey of the east is a paragon of wisdom, compared with his dunce of a brother in Europe; and upon a night's reflection, Mr. Waghorn's donkeys seem to have clearly perceived that he had no notion of easy stages, and was bent on keeping them going as fast as he could, and as long as daylight suffered. So the second day they managed to stumble, and limp, and fall down intentionally four or five times, and to put on a pitiful affectation of fatigue and weariness, —a common dodge, the drivers said, of those knowing animals.

Fortunately he was soon able to dispense with the deceitful donkeys; and embarking on the Nile, under-

took to navigate the boat himself, in order to take soundings and make observations in regard to the route. After brief repose at Rosetta, he set out for Cairo on a *cangé*, a sort of boat of fifteen tons burthen, with two large latteen sails. The captain undertook to land him at Cairo in three days and four nights; but the boat went aground on a shoal, and after tacking for five days and nights, Waghorn lost all patience, and proceeded to his destination upon donkeys. He crossed the desert from Cairo to Suez in four days, on two of which he travelled seventy-four miles. He was thus able to keep his appointment and be at Suez by the 8th December, but there was no sign of the steamer. The wind was blowing right in her teeth; so after waiting two days, with feverish impatience, Mr. Waghorn determined to sail down the centre of the Red Sea, in an open boat, in the hope of meeting the steamer somewhere above Cossier. All the seamen of the locality held up their hands at the proposal of the mad Englishman, and tried to dissuade him. It was the opinion, he knew, of nautical authorities at the time, that the Red Sea was not navigable. But he could not rest quiet at Suez; he had important despatches to deliver; he was commissioned to inquire into the navigability of these waters; and out he would go in an open boat, let folk say what they would, and so he did.

"He embarked," says the narrator of his "Life

and Labours," in *Household Words*,* "in an open boat, and without having any personal knowledge of the navigation of this sea, without chart, without compass, or even the encouragement of a single precedent for such an enterprise—his only guide the sun by day, and the north star by night—he sailed down the centre of the Red Sea. Of this most interesting and unprecedented voyage Mr. Waghorn gives no detailed account. All intermediate things are abruptly cut off with these very characteristic words: '*Suffice it* to say, *I arrived* at Juddah, 620 miles in six and a half days, in that boat!' You get nothing more than the sum total. He kept a sailor's log-journal; but it is only meant for sailors to read, though now and then you obtain a glimpse of the sort of work he went through. Thus: '*Sunday*, 13*th*—Strong, N.W. wind, half a gale, but scudding under storm-sail. Sunset, anchored for the night. Jaffateen Islands out of sight to the N. Lost two anchors during the night,' &c. The rest is equally nautical and technical. In one of the many scattered papers collected since the death of Mr. Waghorn, we find a very slight passing allusion to toils, perils, and privations, which, however, he calmly says, were 'inseparable from such a voyage under such circumstances,'—but not one touch of description from first to last. A more extraordinary

* August 17, 1850.

instance of great practical experience and knowledge, resolutely and fully carrying out a project which must of necessity have appeared little short of madness to almost everybody else, was never recorded. He was perfectly successful, so far as the navigation was concerned, and in the course he adopted, notwithstanding that his crew of six Arabs mutinied. It appears (for he tells us only the bare fact) they were only subdued on the principle known to philosophers in theory, and to high-couraged men, accustomed to command, by experience,—namely, that the one man who is braver, stronger, and firmer than any individual of ten or twenty men, is more than a match for the ten or twenty put together. He touched at Cossier on the 14th, not having fallen in with the *Enterprise*. There he was told by the governor that the steamer was expected every hour. Mr. Waghorn was in no state of mind to wait very long; so, finding she did not arrive, he again put to sea in his open boat, resolved, if he did not fall in with her, to proceed the entire distance to Juddah—a distance of 400 miles further. Of this further voyage he does not leave any record, even in his log, beyond the simple declaration that he 'embarked for Juddah—ran the distance in three days and twenty-one hours and a quarter—and on the 23d anchored his boat close to one of the East India Company's cruisers, the *Benares*.' But now comes the most trying part of his whole undertaking—

the part which a man of his vigorously constituted impulses was least able to bear as the climax of his prolonged and arduous efforts, privations, anxieties. and fatigue. Repairing on board the *Benares* to learn the news, the captain informed him that, in consequence of being found in a defective state on her arrival at Bombay, 'the *Enterprise* was not coming at all.' This intelligence seems to have felled him like a blow, and he was immediately seized with a delirious fever. The captain and officers of the *Benares* felt great sympathy and interest in this sad result of so many extraordinary efforts, and detaining him on board, bestowed every attention on his malady."

It was six weeks before he could proceed by sailing vessel to Bombay, where he arrived on the 21st March, having, in spite of all the drawbacks in his way, accomplished the journey in four months and twenty-one days—quite an extraordinary rapidity at that time. Had he escaped the fever at Juddah, and fallen in with the *Enterprise* at the right time, nearly two months might have been saved.

He had proved the practicability of the overland route, and he now devoted himself to its establishment. In an address to the Home Government and the East India Company, he thus expresses his views :—

"Of myself, I trust I may be excused when I say, that the highest object of my ambition has ever

been an extensive usefulness ; and my line of life—my turn of mind—my disposition, long ago impelled me to give all my leisure, and all my opportunities of observation, to the introduction of steam-vessels, and permanently establishing them as the means of communication between India and England including all the colonies on the route. The vast importance of three months' earlier information to his Majesty's government, and to the Honourable Company,—whether relative to a war or a peace—to abundant or to short crops—to the sickness or convalescence of a colony or district, and oftentimes even of an individual ; the advantages to the merchant, by enabling him to regulate his supplies and orders according to circumstances and demands ; the anxieties of the thousands of my countrymen in India for accounts, and further accounts, of their parents, children, and friends at home ; the corresponding anxieties of those relatives and friends in this country;—in a word, the speediest possible transit of letters to the tens of thousands who at all times in solicitude await them, was, to my mind, a service of the greatest general importance ; and it shall not be my fault if I do not, and for ever establish it."

The scheme which he thus resolutely and enthusiastically declared his adoption of, he lived to carry out, but at the cost of years of weary advocacy, agitation for help, desperate attempts on his own account, or in conjunction with a few enterprising

associates, in the teeth of constant discouragement, official indifference, jealousy, and disguised hostility. The East India Company told him there was no need of steam navigation to the East at all, ordered him to mind his own business and return to field service, circulated reports of his insanity through their agents in Egypt when Waghorn went there to enlist the Pasha in his cause. The overland route, however, was no theory, but an undoubted fact. Waghorn never for a moment relaxed his grasp of it, or doubted its value; and in the end, after unheard of difficulties, disappointments, and opposition, into the long, painful story of which we need not enter, succeeded in establishing the overland route. When he left Egypt in 1841, he had provided English carriages, vans, and horses, for the conveyance of passengers across the desert, placed small steamers on the Nile and Alexandrian Canal, and built the eight halting-places on the desert between Cairo and Suez. He also set up the three hotels in the same quarter "in which every comfort, and even some luxuries, were provided and stored for the passing traveller,—among which should be mentioned iron tanks with good water, ranged in cellars beneath;—and all this in a region which was previously a waste of arid sands and scorching gravel, beset with wandering robbers and their camels. These wandering robbers he converted into faithful guides, as they are now found to be by every traveller; and even

ladies with their infants are enabled to cross and re-cross the desert with as much security as if they were in Europe."

In acknowledgment of his services, Mr. Waghorn received the rank of lieutenant in the Royal Navy, a grant of £1500, and an annuity of £200 a-year from Government, and another annuity of £200 from the East India Company; but he did not live long to enjoy his well-earned rewards. The care, and anxiety, and fatigue he had undergone had shattered his constitution. Through some misunderstanding or mismanagement on the part of the East India Company, rivals were allowed to step in and carry off the chief profits of the overland system, and his last years were embittered by various disputes with the authorities. He died in the end of 1849, by years only in the prime of life; but old, and worn by his labours before his time. Such was the career of the "pioneer of the Overland Route."

But in connection with England's route to India, the name of Monsieur de Lesseps must never be forgotten, nor the great enterprise which, at so much cost, and in spite of so many obstacles, he successfully carried out—the Suez Canal. When he first projected it he met with most of the obstacles which are thrown in the way of great inventions. England, jealous of a scheme which seemed likely to throw into the hands of a foreign power the nearest route to her beloved India, stood sullenly aloof, and refused

to contribute moral or pecuniary support; while some of the most eminent English and foreign engineers openly declared that it could never be carried out. M. de Lesseps, however, was one of those men who, when they have seized a great idea, can never be thrown off it. It had taken full possession of his imagination, judgment, and intellect! he felt that it *could*, and he determined that it *should* be realized. He conquered every difficulty: he raised funds; he secured the support of his own government; and in 1856 he obtained from the Pasha of Egypt the exclusive privilege of constructing a ship-canal from Tyneh, near the ruins of the ancient Pelusium, to Suez.

M. de Lesseps determined that his canal should be cut in a straight line, with an average width of 330 feet, and at an uniform depth of 20 feet under low-water mark, while at each end was to be constructed a sluice-lock, 330 feet long by 70 wide. Further, at each end he proposed to execute a magnificent harbour; that at the Mediterranean end was to be extended five miles into the sea, so as to obtain a permanent depth of water for a ship drawing twenty-three feet, on account of the enormous quantity of mud annually silted up by the Nile; that at the Red Sea end was to be three miles long.

In 1865 the great canal was begun. The Mediterranean entrance is at Port Said, about the middle of the narrow neck of land between Lake

Menzaleh and the sea, in the eastern part of the Delta. Thence it is carried for about twenty miles across Menzaleh Lake, being 112 yards wide at the surface, 26 yards at the bottom, and 26 feet deep. On each side an artificial bank rises some 15 feet high. The distance thence to Abu Ballah Lake is 11 miles, through ground which varies from 15 to 30 feet above the level of the sea. This lake being traversed, there is land again—a troublesome and shifty soil—to Timsah Lake, the canal being cut at a depth below the sea-level of 50 to 100 feet. On the shore of Timsah Lake has risen a new and busy town, the central point of the canal, and named Ismailia, in honour of the present Pasha of Egypt.

A space of eight miles intervenes between the Timsah Lake and the Bitter Lakes, and in this space the cuttings are very deep and difficult. The soil being almost purely sand, the constant labour of powerful dredging machines is constantly required, to prevent the channel from filling up. The deepest cutting occurs at El Guisr, or Girsch, and is no less than 85 feet below the surface: at the water-level it is 112 yards wide, at the summit-level 173 yards. In traversing the Bitter Lakes the course of the canal is marked by embankments. From the southern end of these lakes to Suez, a distance of about thirteen miles, the cuttings are heavy and deep.

After many discouraging failures, M. de Lesseps' great work was completed last year, and the formal

opening of the canal took place in the presence of the Prince and Princess of Wales, and a goodly number of princes, potentates, and distinguished personages. It is now open to navigation from end to end, and ships of considerable tonnage have successfully accomplished the passage. Whether the canal is a *commercial* success may still be doubted. The cost of further deepening and enlarging it, and of maintaining its banks and harbours, amounts to a sum which, as yet, the traffic charges are not at all likely to defray. But, in an engineering sense, the Suez Canal is one of the wonders of this wonderful nineteenth century.

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